















# The Virginia Journal of Science

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MARCELLUS H. STOW



# THE VIRGINIA JOURNAL OF SCIENCE

VOL. 9 NEW SERIES

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No. 1

## MARCELLUS HENRY STOW 1902-1957

Marcellus H. Stow, Robinson professor of geology, professor on the Thomas Ball Foundation, and head of the Department of Geology at Washington and Lee University since 1937, died at his home Wednesday, November 27, 1957. In his passing, Virginia lost one of its most energetic and capable scientists.

Dr. Stow took all of his collegiate and graduate work at Cornell University where he obtained his Ph.D. degree in 1926. In 1927, he joined the staff of the Department of Geology at Washington and Lee University, where he rose through the academic ranks to succeed the late Dr. H. D. Campbell as head of the Department of Geology in 1937.

Stow made extensive studies of the Oriskany sandstone and published several excellent papers dealing with the sedimentary environment and provenance of the formation. His specialty was heavy-mineral petrography. Beginning in the summer of 1933 he conducted field geological studies and research with the Yellowstone-Big Horn Research Association which continued for several summers thereafter. He applied the methods of heavy-mineral petrography to a study of the sedimentation, volcanism, and orogeny in the Big Horn Basin and Beartooth Mountains, which was published in the Geological Society of America, Bulletin, in 1937, 1938, and 1947. He is credited with the recognition and correct interpretation of the Fincastle conglomerate, which has figured prominently in recent reinterpretations of the geologic history of the Appalachian geosyncline.

From 1942-45 he served as a deputy director of the mining division of the War Production Board. Late in 1945 he became chief of the mining branch of the Civilian Production Administration. He had been a member of the Governor's Advisory Council on Virginia Economy since 1948 and was chairman of the committee on mining in 1948-49. In 1953-54 he served as chairman of the Governor's Advisory Committee on Geology and later served as special geological consultant to the director of the Department of Conservation and Development. Also for several years, he served as a geological consultant to the Atomic Energy Commission and made extensive surveys for uranium minerals in the southeastern states. He was chairman of the James River Monograph Committee and editor-in-charge of the Virginia Academy of Science's "James

River: Past, Present, and Future" which was published by the Academy in 1950. Dr. Stow was also active in other affairs of the Virginia Academy of Science, holding offices as council member from 1939-1946 and as president of the Academy 1942-1943. For many years he served as a member of the Advisory Board of the Virginia Fisheries Laboratory, the Virginia State Museum Commission, and with various committees of the Southern Association of Science and Industry. He served as a member of the Board of Directors of the Southern Research Institute since 1945. He was also a Fellow of the Geological Society of America and a member of the Society of Economic Geologists and Paleontologists, Sigma Xi, Phi Kappa Phi, Sigma Gamma Epsilon, Sigma Phi Epsilon, and Phi Beta Kappa. He received a War Department citation in December, 1945 for his work with the War Production Board. He was a member of the Cosmos Club. He also served as contributing editor to *The Commonwealth*, published by the Virginia Chamber of Commerce.

The Department of Geology at Washington and Lee University, under his direction, developed into one of the outstanding undergraduate departments of geology in the southeastern United States. Dr. Stow's advanced students were always in attendance at the annual meetings of the Geology Section of the Virginia Academy of Science where nearly every year one or more of them presented a paper on work done on some phase of Virginia geology, studied under the direction of their able mentor. His service on numerous university committees made him one of the most valuable members of the Washington and Lee faculty.

"Mar" had an unusual facility for working with people. His quiet, easy-going, jovial manner was blended with wisdom, energy and prodigious drive. All these qualities he poured into his academic and professional activities with outstanding results. He was widely sought after by government and scientific groups working on improvement of the economic conditions in Virginia and the South. His activities were invariably characterized by fairness, patience, and sound judgment. Virginia has lost a valuable liaison between science and government. Not all of the outstanding contributions Stow made to State government are well known to his fellow scientists, but many of his special assignments required qualities which would have exhausted the patience and forbearance of a lesser man. Among his most recent publications was "The Mineral Resources and Mineral Industry of Virginia," a summary report of the Committee on Mining of the Advisory Council on the Virginia Economy, of which he was chairman in 1948-49.

The loss we have sustained in losing "Mar" in the very prime of life is indeed a heavy one. But life need not be long to be rich and full. As measured not in years but in accomplishment "Mar" lived a full, valuable, dedicated life of service.

—Byron Cooper, *Virginia Polytechnic Institute*.

# A Review Of The Anoetidae (*Acari*)

Roscoe D. Hughes

and

Caroline Goode Jackson

Medical College of Virginia

---

## ACKNOWLEDGMENTS

The authors are greatly indebted to Miss Jane Boyd Lee and Mrs. Ruth Morrissey Bane for technical aid and for assistance in the preparation of the manuscript; to students and others whose names appear in the text for collecting a number of species of anoetids; and especially to Dr. Edward W. Baker for his invaluable advice during the course of this study and for reading the manuscript. The publication of this paper has been made possible by generous financial support from the Adora Wardell Sexton Foundation, Inc., A. D. Williams Research Fund of the Medical College of Virginia, and the Richmond Area University Center. The authors also wish to acknowledge their indebtedness to Dr. L. van der Hammen, Rijksmuseum van Natuurlijke Historie, Leiden for permission to use a number of A. C. Oudemans, hitherto unpublished drawings.

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## INTRODUCTION

Not since the publication of Michael's "British Tryoglyphidae" (1901-1902) has there been an attempt to review the taxonomy and biology of the family Anoetidae.\* A critical review is desirable and urgent for the reason that some of the more recent taxonomic papers, as well as many of the older ones, are so lacking in essential details that taxonomic confusion in this family prevails. This study has inevitably brought to light certain taxonomic categories of dubious validity. However, we take the view that so few of the potentially large number of species in the Anoetidae have been described that we do not as yet have a sufficiently large sample upon which a logical, complete revision can be based. Accordingly, we have deliberately refrained from attempting major revisional changes at this time.

Our interest in the Anoetidae is not purely taxonomic. Their ease of culture under laboratory conditions, relatively short life cycle, world wide distribution, omnipresence in a variety of habitats, small numbers of chromosomes, and enormous potential number of species are some of the factors which make them ideal material for problems in speciation. Parthenogenesis appears to be typical for this group, yet in at least one species pseudofertilization, or insemination seems to be necessary to initiate development of male producing eggs. However, the sex ratio obtained in this instance suggests that we are not dealing with a typical bisexual species. The remaining species so far examined fall into two distinct parthenogenetic groups, namely: arrhenotokous species, and thelytokous species. Since arrhenotoky and thelytoky are considered to involve quite different cytogenetic mechanisms, their occurrence in the same family is unusual though not unique. If typical bisexual species are later found in this family, as has been reported for some families of mites, the Anoetidae would indeed be remarkable for its reproductive plasticity. The evolution of parthenogenesis in this family and the elucidation of the mode, or modes of sex determination, also pose problems of great interest.

## MATERIALS AND METHODS

*Preparation of specimens for study.* — The most satisfactory slides for study are made of specimens first cleared by a method described by H. H. Keifer (1935) and then mounted in Hoyer's medium. (Baker and Wharton, 1952).

---

\*Attention is invited to a comprehensive study of German Anoetidae by Dr. Rita Scheucher which was published while our paper was in press. (See addendum to Bibliography).

*Keifer's clearing agent*

Melted phenol	4 cc.
Lactic acid solution	12 cc.
Resorcinol	1/2 gm. (or less)
Potassium iodide	1/2 gm.
Hydrochloric acid solution conc.	16 drops

Anoetids tend to accumulate a large number of crystals, or pseudocrystals (see below) in body spaces which render them opaque, and obscure the finer cuticular details. Keifer's clearing agent readily takes care of this problem. Two or three drops of clearing solution are placed on the end of a clean slide. One or many living mites are transferred to the medium. The slide is passed over a low flame and gently heated for 1-2 minutes, or until the mites are cleared. A drop of Hoyer's mounting medium is added to the middle of the slide and the mites transferred directly to this from the clearing medium with needles, and a cover slip added. Gentle pressure on the cover slip at this time will aid in orienting mites as desired, and extending the appendages. The cuticle of freshly prepared specimens is slightly yellow. Critical study of faint apodemata, and minute setae is best undertaken with fresh slides. However, specimens prepared as above remain in excellent condition indefinitely although gradually becoming quite transparent. It is often desirable to study living specimens in order to distinguish between movable and incipient joints of appendages, observe the functioning of mouth parts and suckers, determine the arrangement of minute setae, and to make other observations which are facilitated by movement, or change of position. An aqueous solution of methocellulose (Methocel) is excellent for this purpose. Living specimens mounted in this solution can be studied with an oil immersion lens, or lower power, for a considerable period.

*Methods of collection.* — Since anoetids are likely to be found wherever there are fermenting organic compounds, one satisfactory way of collecting is simply to examine bits of organic material under a hand lens and preserve any mites found in 70% alcohol, or inoculate culture media with specimens for future study in the laboratory. A much preferred method of collection is by trapping. Old milk bottles, containing a suitable culture medium, and partially closed by a cap with a small segment removed in order to allow the entrance of insects but prevent the entrance of mice, are quite suitable. The traps should be smeared with over ripe bananas, or other actively fermenting materials to attract insects and other small invertebrates. In this way any deutonymphs which are attached to insects and other animals entering the traps, and possibly originating from distant sources and varied ecological niches, may be induced to detach from their hosts, and metamorphose into trophic tri-

tonymphs. A new colony may be started by a single individual if the resulting adult is a parthenogenetic female, and if the culture medium is suitable. Trap bottles are firmly plugged with cotton before bringing to the laboratory, where they are examined periodically, and are discarded in 3-5 weeks if no mites can be seen. The most effective traps appear to be those placed on the ground in damp woods, compost piles, near decaying logs, and orchards. Those suspended from tree branches are nearly as effective. Traps should not be placed in full sunlight, and should be so inclined that they will not collect rain water.

*Culture technique and media.* — Nearly all species of the Anoetidae so far encountered are easily cultured in a wide variety of media. They appear to thrive best when fermentation of organic matter is evident. Anoetids are surface feeders, and most seem to prefer a thin film of fluid in which to wade while feeding. It is presumed that they engulf yeasts, and other microorganisms. Most species thrive in the laboratory on standard cornmeal — molasses — agar medium or stable fly medium to which wood shavings have been added, or a combination of both.

*Cornmeal — molasses — agar medium.* —

Water	931 cc.
Agar	19 gm.
Molasses	169 cc.
Cornmeal	125 gm.
Moldex (10% in 70% alcohol)	9 cc.

*Stable fly medium.* —

Standard N.A.I.D.M. Peet-Grady media	600 gm.
Shavings	300 gm.
Agar	100 gm.
Water	4500 cc.
Moldex (10% in 70% alcohol)	50 cc.

About 100 ml. of medium is placed in 250 ml. Erlenmeyer flasks and tightly plugged with absorbent cotton wrapped in gauze. In order to provide a tight plug seal, the inside of the flask neck is smeared with vaseline. Contamination of stocks can be a problem, hence sterile procedures are necessary for maintaining species purity. In making new stocks a bit of food containing mites from old stocks is transferred to the new medium. Most species require a change of culture medium every 3-6 weeks.

TAXONOMIC POSITION OF THE FAMILY ANOETIDAE  
(Oudemans, 1904)

The Anoetidae is a family under the superfamily Anoetoidea, sub-order Sarcoptiformes of the order Acarina.

## DIAGNOSIS OF THE FAMILY ANOETIDAE

(Plates 1-12)

Free living, rarely parasitic; terrestrial, usually on decaying organic matter, rarely water dwelling; soft-bodied; whitish, opaque; dorsum smooth, pitted, or sculptured; venter typically smooth; dorsal suture between propodosoma and metapodosoma more or less distinct; dorsal idiosoma of adults occasionally with prominent protuberances; with dorsal opisthosomatic bursa copulatrix; adults with one pair of opisthosomatic "oil glands;" females with transverse genital slit; adults with two pairs of ringlike structures, typically without true anal or genital suckers; deutonymph with one pair of suckers and one to three pairs of sucker-like discs on suctorial plate; crystals or pseudocrystals in body cavity; no stigmata or tracheae, but adults with minute cuticular pit-like structures; with movable gnathosoma; chelicerae dentate, rarely simple, and functionally non-chelate, but bearing a median chelicercal process which may represent the vestige of the movable portion of a true chela; pedipalpi with two distinct simple, usually flagellum-like setae. Setae simple, dorsal setae rarely pilose; chemo-sense organ legs I-II (seta *tal*); legs I-II with atypical, non-tapering setae (*g3*) with rounded end; claws strong, typically curved, and sessile (Plates 3, 5).

It will be noted below that the genera of this family are established solely on the characteristics of the deutonymphs (hypopi). The reason for this is partly historical, since in a large percentage of the described species only the deutonymphs are known. The morphology of the adults of species which have been adequately described show no clear cut characters which permit their separation into groups corresponding to the genera based on deutonymphs. At the present it is not feasible to separate the various species into genera on the basis of the adult characteristics. The adults of one genus (based on the deutonymphs) do not show obvious common characteristics which differ from the species of other genera. The use of adult characteristics in the establishment of genera must await a description of a larger sample of anoetids.

KEY TO THE GENERA OF THE FAMILY ANOETIDAE —  
BASED ON DEUTONYMPHS (HYPOPI)

1. Suctorial plate with 3 pairs of discs or suckers of equal size .... *Sellea*  
Suctorial plate with more or less than 3 pairs of discs or  
suckers ..... 2
2. A terminal tarsal seta on legs I-IV conspicuously flattened  
and spoon-shaped ..... *Lipstorgia*  
No spoon-shaped terminal tarsal seta on leg IV ..... 3



3. With divided claw on legs I-III ..... *Myianoetus*  
Without divided claw on legs I-III ..... 4
4. Setae or discs on coxae I and/or III ..... 5  
No setae or discs on Coxae I and/or III ..... 7
5. Setae on coxae I and/or III ..... 6  
Discs on coxae I and/or III ..... 9
6. Large seta on coxa I, no seta on coxa III ..... *Chiropteranoetus*  
Minute or hairlike setae on coxae I and III ..... 10
7. No seta *vm1* laterad or mesiad of coxa IV disc *di3* ..... *Anoetostoma*  
With seta *vm1* laterad or mesiad of coxa IV disc *di3* ..... 8
8. With seta *vm1* laterad of coxa IV disc *di3* ..... *Zwickia*  
With seta *vm1* mesiad of coxa IV disc *di3* ..... *Mauduytia*
9. Disc *dil* on coxa I and *di2* on coxa III ..... 11  
Disc on coxa I or III ..... 10
10. Disc on coxa I only ..... *Anoetoglyphus*  
Disc on coxa III only ..... *Glyphanoetus*
11. Median disc *pd1* of suctorial plate larger than other plate discs  
*pd2* and *pd3* ..... *Histiostoma*  
All discs of suctorial plate, *pd1*, *pd2*, *pd3* equal in size *Prowichmannia*
12. Hairlike seta on coxae I, III, and IV; with "eyes" on anterio-lateral  
margin of hysterosoma ..... *Bonomoia*  
Minute seta on coxae I, III, and coxa IV mesiad of disc  
*di3*; no "eyes" ..... *Anoetus*

## DESCRIPTION AND BIOLOGY OF A TYPICAL SPECIES

*Histiostoma julorum* (Koch), 1841

(Plates 1-13)

*Hypopus julorum* Koch, 1841; *Anoetus julorum* (Koch), 1841 [Vitzthum, 1929]; *Uropoda julorum* (Koch), 1841 [Dujardin, 1849a]; *Histiostoma julorum* (Koch), 1841 [Oudemans, 1937]; *Hypopus ovalis* Gervais, 1844; *Histiostoma gervaisi* (Gervais), 1844 [Oudemans, 1937]; *Hypopus vulpis* Dujardin, 1849; *Histiostoma vulpis* (Dujardin), 1849 [Oudemans, 1937]; *Anoetus sumatrensis* Oudemans, 1903.

*H. julorum* has been selected for detailed study because its morphology, habitat, nutritional requirements, and life cycle are rather typical of the family Anoetidae. In addition, it is widely distributed and is easily collected in the warmer seasons of the year.

## DESCRIPTION OF FEMALE

*General features* (Plates 1-3). — Average length 0.435 mm.; aver-

age width 0.275 mm. Body pear-shaped, especially when gravid; whitish; semi-transparent; smooth, except for rostrum, which is faintly granular and slightly sculptured. Body spaces contain crystals, or pseudo-crystals, of characteristic shape and sometimes numerous enough to render the body virtually opaque. (Plate 4).

*Gnathosoma* (Plate 4). — The gnathosoma is directed anteriad and ventrad when in the feeding position and is partially obscured by the rostrum dorsally. The chelicerae are long, attenuated, sub-chelate, and each bears approximately twelve, nearly equal, fine teeth distally. Proximad and mesiad of the toothed region, a frayed cheliceral process is seen. Proximad and laterad of the toothed region, is also seen a thin whiplike cheliceral flagellum slightly longer than the toothed region. These processes together with the toothed distal portions of the chelicerae appear to serve as rakers when the animal is feeding. Several other fine processes are associated with the chelicerae at their bases. These extend to a position laterad of the heavily sclerotized hypopharynx. The two jointed pedipalps bear two conspicuous setae distally. The anterior setae *pp1* are long and whip-like and extend laterally and caudally. The posterior setae *pp2* are very fine, about one-third the length of the anterior setae, and are directed caudally. Three extremely minute spicules can be seen under favorable conditions on the dorsal surface of the distal joint of the pedipalps. A membranous sheath partially surrounds the base of the distal joint. A pair of sub-oral setae *pp3* are located ventrally on the proximal joint of the pedipalps. The proximal joint of the pedipalps extends anteriorly to form a trowel-shaped structure on the mesial surface. The funnel-shaped opening to the gut can be seen at the base of the hypopharynx under favorable conditions. A thin, membranous structure extends anteriorly from the region of the base of the hypopharynx to the middle of the first pedipalpal joint, which is provisionally called the labium.

*Venter.—Propodosoma.*—The posterior limits of the gnathosoma and anterior limits of the propodosoma are marked by apodemata *a1*. Apodemata *a1* join in the midline to form a short sternum. Apodemata *a2* and *a3* join mesially to form the limits of coxae I and II. Ventrally, the propodosoma bears a single pair of coxal setal *vp1*, about the same length as seta *pp3*. The genital opening is a wide transverse slit situated on a line connecting apodemata *a4*. It is distensible and appears to open in a ventral direction and is supported by a structure appearing as a faint longitudinal crease in the midline. The genital opening marks the posterior limit of the propodosoma on the ventral surface. *Metapodosoma.* — A line connecting apodemata *a8* marks the posterior limits of the metapodosoma on the ventral surface. The metapodosoma bears two pairs of conspicuous ring-like structures *r1* and *r2*. The anterior pair of ringlike structures *r1* is in a lateral position between apodemata *a4* and *a5*, and each is more or less elliptical in shape. Each of the posterior pair is almost circular, but some-

times appearing oval in shape, is more mesiad in position and lies on a line between coxae IV. Ventrally the metapodosoma bears three pairs of setae, as follows: one pair of paragenital setae *vm1*, near the mesial end of apodemata *a5*; one pair of coxal III setae *vm2*, directly below setae *vm1*; and one pair of coxal setae *vm3* posteriad and laterad of the posterior ringlike structures *r2*, and mesiad of coxae IV. *Opisthosoma*. — Ventrally the opisthosoma bears three pairs of setae as follows: anterior anal *vo1* very minute and in a position close to the antero-lateral margin of the anus; middle anal *vo2* about the same length as *vm3* and in a position laterad of, and on a line with, the posterior margin of the anus; posterior anal *vo3* mesiad and posteriad of *vo2*, and about twice their length. The anus is a conspicuous longitudinal slit lying in the midline of the ventral surface of the opisthosoma. A pair of minute pit-like structures *vpil* are found at the extreme margin of the opisthosoma laterad and posteriad of *vo3*,

*Dorsum: Propodosoma*. — The propodosoma bears four pairs of setae, as follows: rostral *dp1*; cervical *dp2*; inner propodosomatic *dp3*; and outer propodosomatic *dp4*. Seta *dp3* is slightly shorter than *dp4* and about half again as long as seta *dp2*. Seta *dp1* is equal in length to *dp2* and, as Nesbitt (1954) has pointed out for members of the Acaridae, they do not appear to be typical setae. These seem to be more like extensions of the rostral cuticle and lack the rounded bases of regular setae. *Metapodosoma*. — Dorsally the metapodosoma is delimited anteriorly by a faint but definite sulcus and posteriorly by a line connecting apodemata *a8* projected to the dorsal surface. The metapodosoma bears five pairs of setae on the dorsal surface about half again as long as setae *dp3*, as follows: *dm1* mesiad in position; *dm2* sub-marginal in position and laterad and anteriad of *dm1*; *dm3* sub-marginal in position and laterad of *dm2*; and *dm5* marginal in position and at the level of trochanters IV. A pair of minute imperforate pits, or pore-like structures *dpi1*, are found posteriad of *dm3*. These pits are suggestive of vestigial respiratory pores, or possibly the bases of setae which have been lost, as Nesbitt (1954) has suggested.

*Opisthosoma*. — The dorsal surface of the opisthosoma bears seven pairs of prominent setae of approximately equal size and having a length equal to *dm1*, as follows: *do1* mesiad and laterad of excretory pore; *do2* is in a position slightly anteriad and laterad of *do1*; *do3* is sub-marginal and in a position posteriad and laterad of *do2*; *do4* near the posterior end of the opisthosoma and mesiad in position; *do5* slightly anteriad and laterad of *do4*; *do6* posteriad and laterad of *do5*; *do7* on the margin of the opisthosoma and slightly posteriad and laterad of *do4*. Dorsally the opisthosoma bears three pairs of pit-like structures, as follows: *dpi2* posteriad and laterad of seta *do2*; *dpi3* mesiad of seta *do3*; *dpi4* posteriad of seta *do3*. A pair of so-called excretory pores ("oil glands") lie in a position between *do1* and *do2*. Beneath these conspicuous raised pores can be seen

a clear vesicle. The bursa copulatrix lies in the mid-line on a level with seta *do5*. Details of this structure are shown in Plate 2.

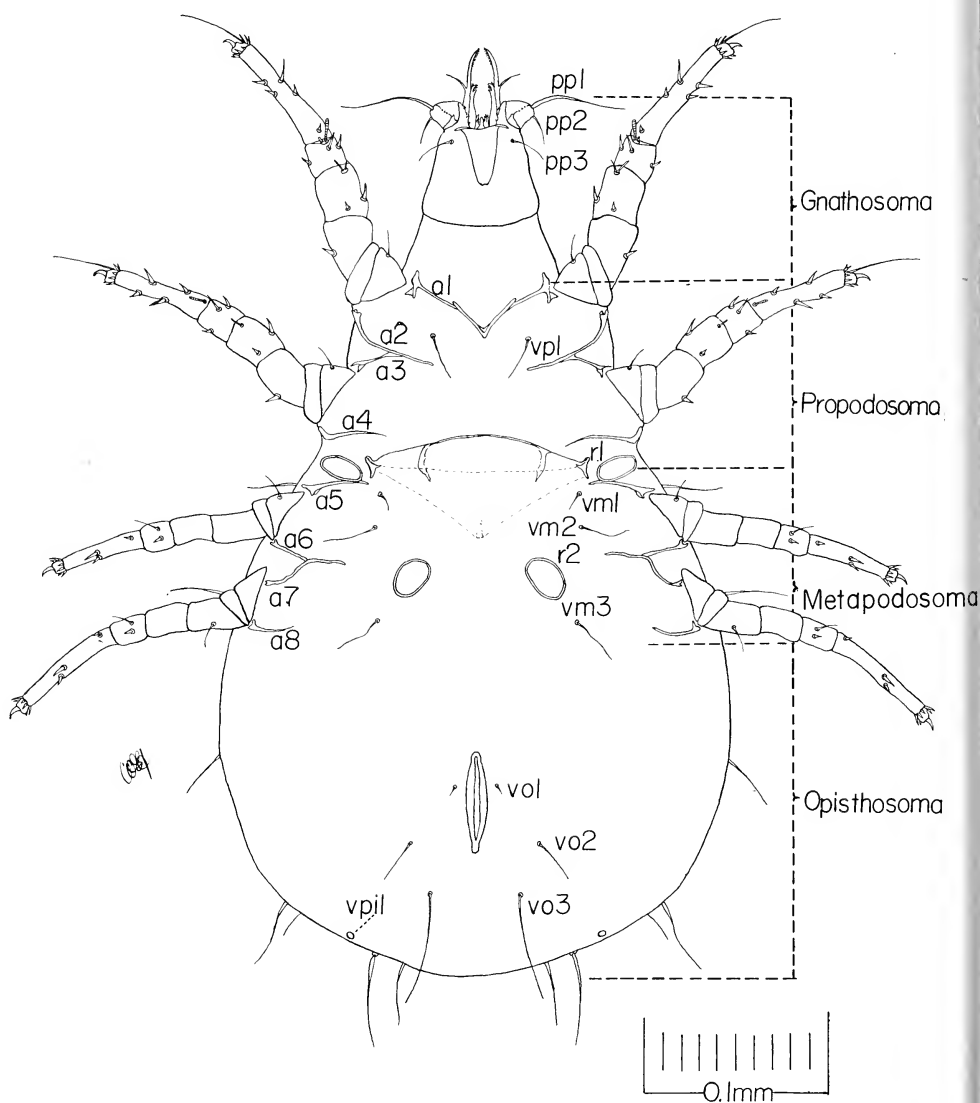


Plate 1 — *Histiostoma julorum* female. Ventral view.

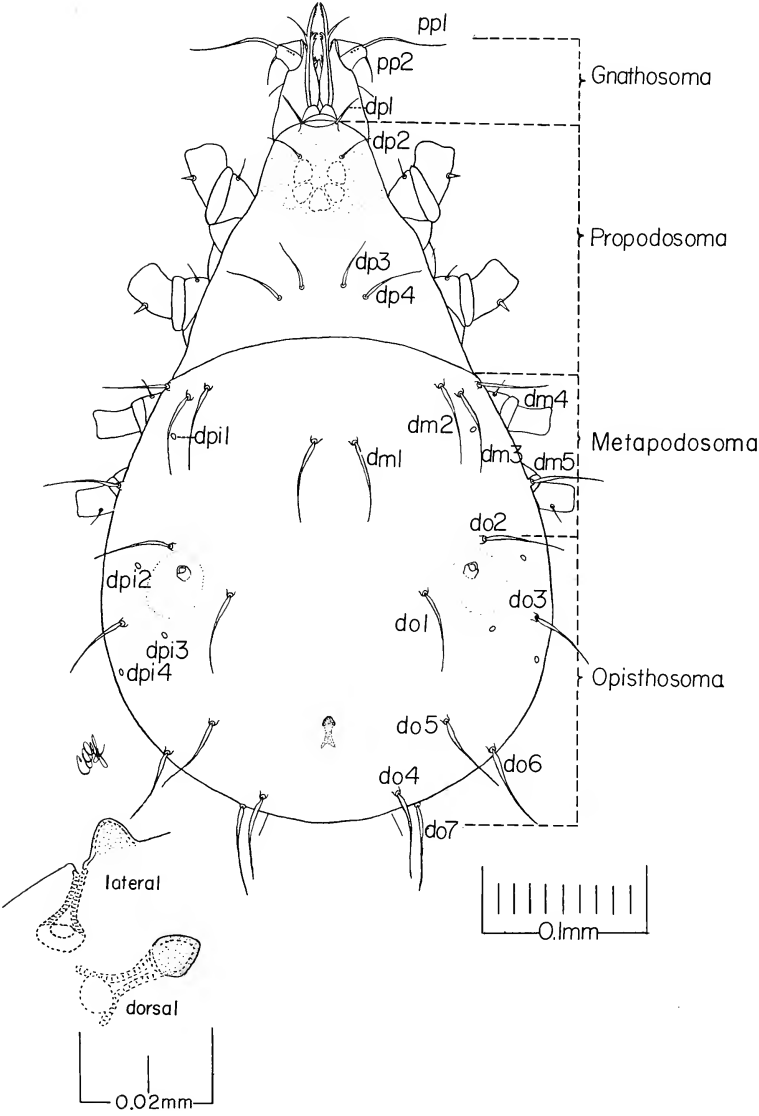


Plate 2 — *Histiotoma julorum* female. Dorsal view. Lower left, bursa copulatrix.

*Legs:* (Plates 1,3). *Leg I.* — The first leg is the most massive of the four legs. It bears many setae of various sizes and shapes, as follows: *coxa* — seta on ventral surface and previously described under the propodosoma *vp1*; *trochanter* — one thin seta *t*; *femur* — one spine-like seta *f*; *genu* — two spine-like setae *g1* and *g2*, and a pair originating from the same base, with rounded tips, and probably function as micro-sensory organs *g3* and *g4*; *tibia* — three spine-like setae *ti1*, *ti2*, and *ti3*; *tarsus* — a striated, club-shaped, macro-sense organ *ta1*, and micro-sense organ *ta2* with a rounded tip and arising from the same base as *ta1*; proximal spine-like setae *ta3* and *ta4*; median spine-like setae *ta5*, *ta6*, and *ta7*; seven spine-like setae surrounding claw — setae *ta8*, *ta9*, *ta10*, *ta11*, *ta12*, *ta13*, and *ta14*; a thin seta with a rounded end *ta15*, and a whip-like seta *ta16*. *Leg II.* — Leg II bears the following setae; *coxa* — appears to be no setae, except possibly the paragenital seta *vm1*, which may represent a coxal seta displaced posteriorly; *trochanter* — a thin hairlike seta *t*; *femur* — a spine-like seta *f*; *genu* — two spine-like setae *g1* and *g2*; a micro-sense organ with a rounded tip *g3*, similar in appearance to *g3* on leg I; *tibia* — three spine-like setae *ti1*, *ti2*, and *ti3*; *tarsus* — has apparent counterparts of all tarsus I setae except those corresponding to I-*ta2*, I-*ta3*, and I-*ta15*. *Leg III.* — The number of setae of this leg is still further reduced as compared with leg II. These setae are as follows: *coxa* — seta *vm2*; *trochanter* — one long seta *t*; *femur* — no setae; *genu* — no setae; *tibia* — seta apparently corresponding to I-*ti2* missing; *tarsus* — by comparison with tarsus I, *ta1*, *ta2*, *ta3*, *ta6*, *ta15*, and *ta16* are missing. *Leg IV.* — This leg has the same number of setae as leg III but the arrangement is slightly different. *Coxa* — seta *vm3*; *trochanter* — no setae; *femur* — seta *f*; *genu* — no setae; *tibia* — by comparison with leg I, seta *ti2* missing; *tarsus* — by comparison with leg I, seta *ta1*, *ta2*, *ta3*, *ta6*, *ta15*, and *ta16* are missing. *Claws.* — Claws of all legs spine-like, slightly curved, and equal in size.

## DESCRIPTION OF MALE

*General features.* — (Plates 4, 5). Average length 0.320 mm.; average width 0.165 mm. The male is conspicuously smaller than the female primarily because of the reduced size of the hysterosoma. Hence, the body is more rectangular than pear-shaped. Crystals or pseudo-crystals are present as in the female. Unlike the female the rostrum of the male does not appear to be sculptured or granular and the hysterosoma has several pairs of more or less conspicuous bosses.

*Gnathosoma.* — There are no differences between the gnathosoma of the male and female worthy of note.

*Venter: Propodosoma.* — Ventrally the number and arrangement of the setae and apodemata are the same as for the female, except apode-

mata  $a2$  and  $a3$  after uniting continue and almost meet in mid-line. Also unlike the female, apodemata  $a4$  and  $a5$  unite and continue toward the mid-line. *Metapodosoma*. — Ventrally there are four round, or almost round ringlike structures  $r1$  and  $r2$  corresponding to similar structures in

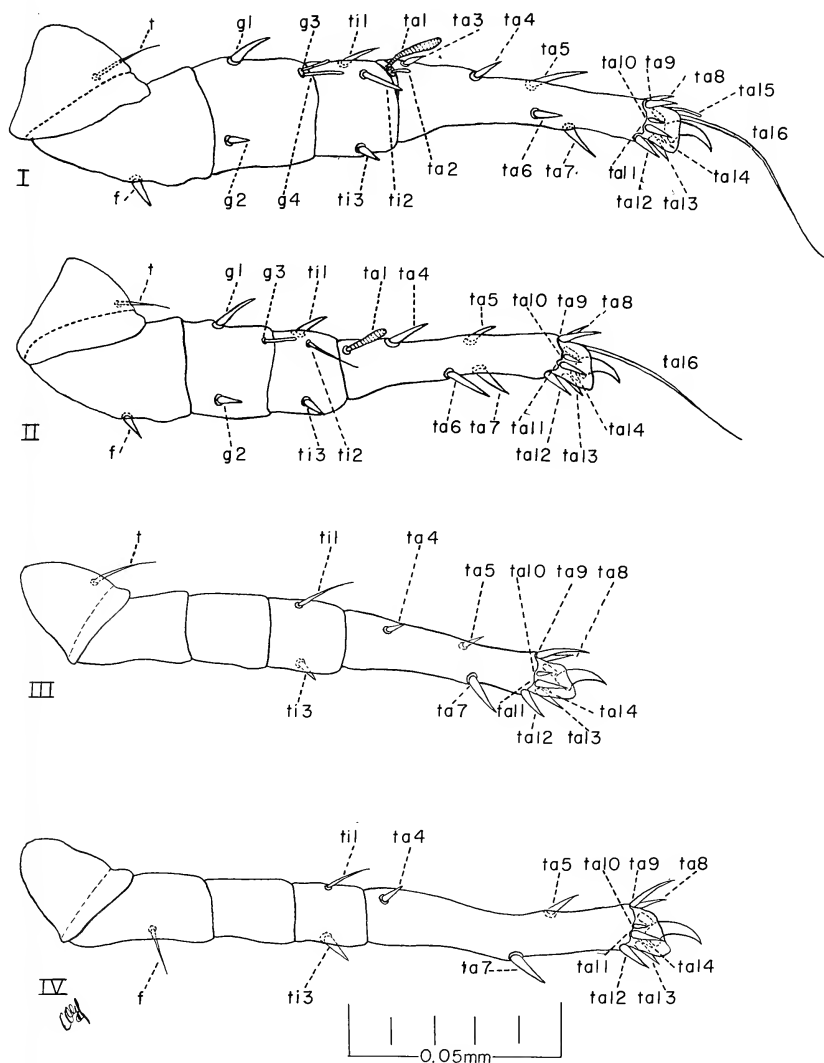


Plate 3 — *Histiotoma julorum* female. Dorsal view of legs.

the female but somewhat smaller. These lie close together between coxae IV and above external genitalia. What is assumed to be setae *vm1* have come to lie antiad and slightly laterad of the anterior ring-like structure *r1*. Setae *vm2* and *vm3* have positions similar to those of the corresponding setae in the females. *Opisthosoma*. — The opisthosoma is much reduced in size as compared with the female. Ventrally the number and arrangement of setae are the same as for the female, except as follows: seta *vo1* is three times as long; seta *vo2* is about the same length but more mesially and posteriorly placed; seta *vo3* is marginal in position. A single pair of pit-like structures *vpil* is found in the same relative position as in the female. The position of apodeme *a8* and the position of the anus are similar to that of the female. Bordering the anterior margin of the anus is the conspicuous, highly sclerotized genital apparatus. (Plate 4.) The male genitalia and associated structures are complex and difficult to interpret. The penial seta is a short chitinized hinged process normally directed posteriorly. The base or anterior end appears to be supported by two lateral winged chitinous structures. A pair of small lateral chitinous bars, each having a minute spicule, lie on either side of the penial seta. These do not appear to be true setae but rather chitinous extensions of the bars. A pair of posteriorly directed processes can be seen to lie on either side of the anus. At the anterior end of the anal slit a pair of spicules can be seen which have the appearance of being true setae.

*Dorsum: Propodosoma*. — Dorsally the relative size and arrangement of the setae are the same in both male and female. *Metapodosoma*. — The metapodosomal pit-like structures *dpil*, and setae *dm1* — *dm5* are similar in size and arrangement to corresponding pit-like structures and setae in the female. *Opisthosoma*. — The type, size, and arrangement of the setae, the position of the excretory pores, and the number and position of the pit-like structures are very similar to those of the female. However, the male has one less pair of setae than the female. It is assumed that this is seta *do7* on the insecure grounds of relative position. It is possible that the minute spicules on the posterior margin of the genital plate, which were referred to above, are true setae. In this case ventral setae *vo1*, *vo2*, and *vo3* would become *vo2*, *vo3*, and *do7* respectively, and the spicules would become *vo1*. Thus, the number of body setae in the male and female would correspond and presumably be homologous. The position taken for the time being is that the spicules are not true setae and cannot be homologized with seta *vo1* in the female, and consequently the male has one pair less of opisthosomatic setae.

*Legs: (Plates 4,5). Leg I*. — Leg I of the male gives the appearance of being somewhat more massive than leg I in the female. Upon closer examination the difference in size is due primarily to the thicker and shorter male tarsus. The number of setae is the same in the male and female. The relative sizes and arrangement of the setae of the male



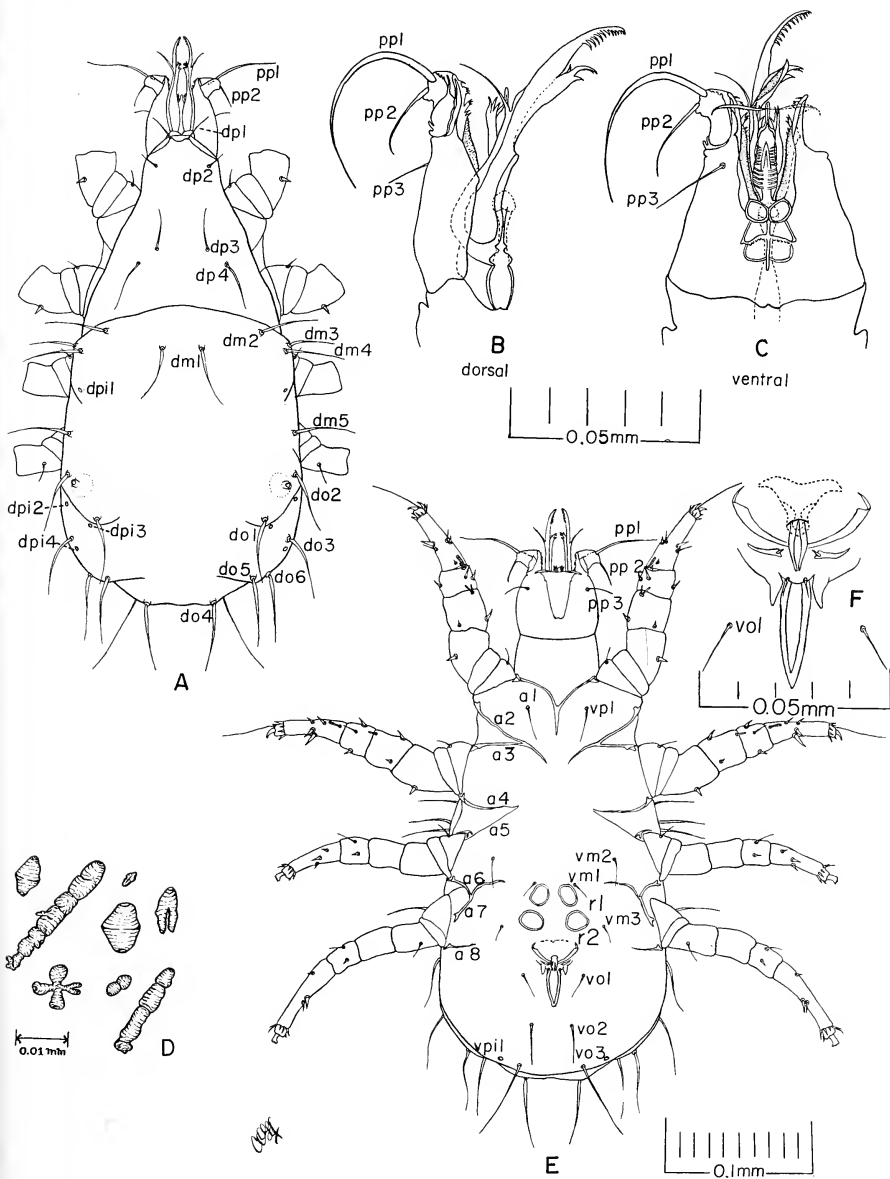


Plate 4 — *Histiotoma julorum*. A — male, dorsal view. B and C — details of gnathosoma. D — typical body crystals. E — male, ventral view. F — details of external genitalia.

are so similar to that of the female that the description of the setae for the latter generally apply, except as follows: setae *ta4-ta7* are less separated; *ta6* is longer and thinner; *ta7* is twice as massive; *ta15* is a massive claw-like structure instead of thin blunt seta. The claw is somewhat heavier than that of the female leg I. *Leg II.* — Male leg II is very similar to that of the female. The tarsus is slightly shorter than in the female and the mid-tarsal setae and claw give the appearance of being somewhat heavier. *Leg III.* — There are only very minor differences between leg III of the male and the female except for the very unusual serrated claw of the former. Tarsus III of the male is somewhat shorter than tarsus III of the female. *Leg IV.* — The only conspicuous difference between leg IV of the male and female is that the claw of the male is serrated as in leg III. The male tarsus is again slightly shorter than in the female. *Claws.* — Claws legs I-II are similar to those of the female. The peculiar serrated claws of the male legs III-IV are unique among the anoetids so far studied.

#### DESCRIPTION OF LARVA

*General features.* — (Plate 6). Average length 0.175 mm.; average width 0.115 mm. With the exception of a few conspicuous features the larva is in effect a miniature adult female. Gnathosomal structures are the same as in the female. As is typical of other acarids only the first three pairs of legs are found in the larva. The number, arrangement, and relative size of the leg setae of the larva virtually duplicate the condition found in the corresponding legs of the female. The exception to this statement is that trochanter setae *t*, of female legs I-II, and III have not made their appearance. The opisthosoma is relatively smaller than in the female. The dorsum of the larva differs from the dorsum of the adult female. The dorsum of the larva differs from the dorsum of the adult female separate boss with adjoining setal bosses sometimes fusing to form a single large prominence. Also there are two large elevated surfaces, one anterior of the conspicuous dorsal sulcus, and the other posterior of this sulcus. It may be noted that there are no primary or secondary sex structures. Also there are no pit-like structures, and no excretory pores in the larva. Opisthosomatic setae *do4*, *do6*, and *do7* of the adult female, as judged by relative positions of such setae in the adult, do not make their appearance in the larva. No granulation or sculpturing of the rostrum is seen. The venter of the larva differs from the venter of the female, as follows: there is an absence of sex structures; no pit-like structures can be seen; only the extremely tiny body setae *vp1*, *vm2*, and *vo3*, which would seem to correspond to like named setae of the female, can be seen. It is interesting that setae *vm1*, *vm3*, *vo1*, and *vo2* are missing. There is only one pair of ringlike structures, and these are found in a lateral posi-

tion posteriad of the first pair of legs instead of posteriad of the second pair of legs in the adult female or on the metapodosoma as in the male. The ringlike structures of the larva are morphologically similar to ringlike structures of nymphs and adults except they lie on slight prominences.

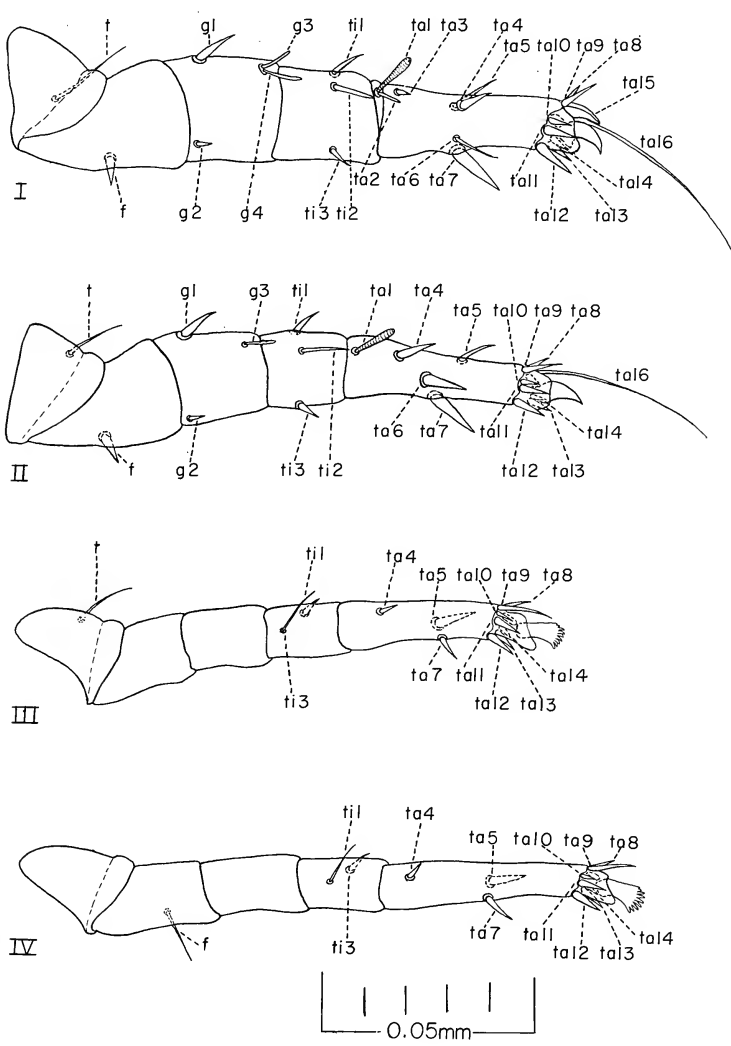


Plate 5 — *Histiostoma julorum* male. Dorsal view of legs.

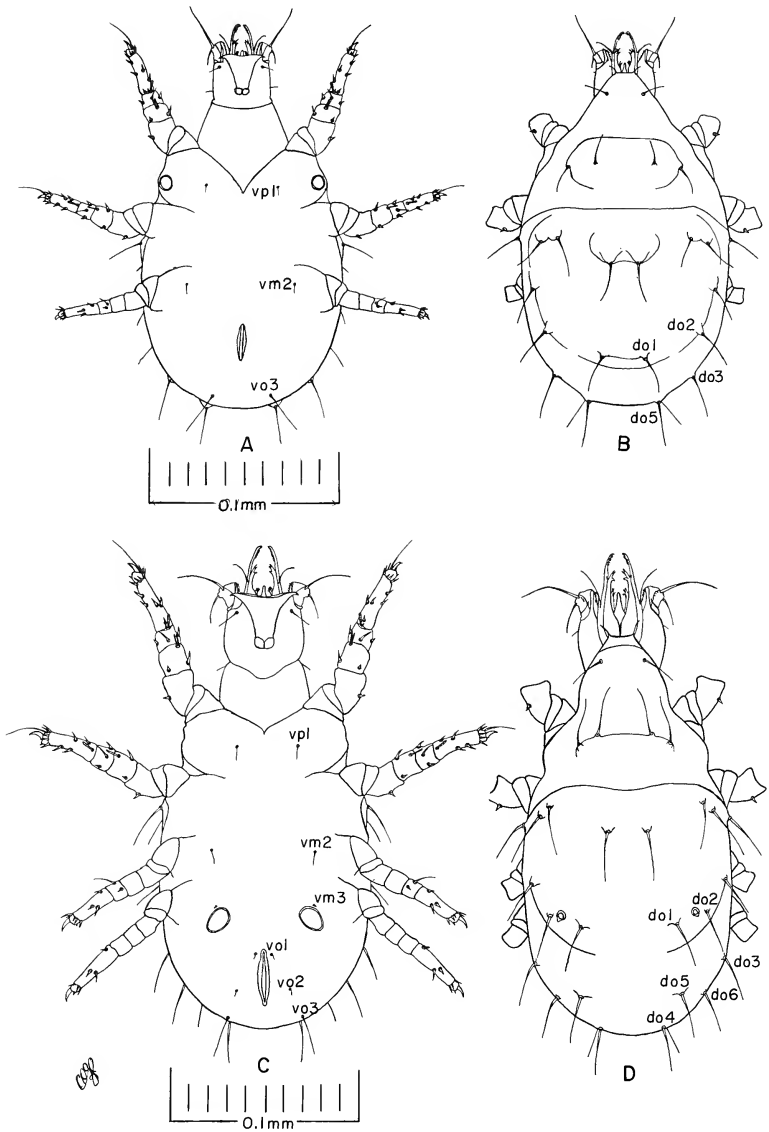


Plate 6—*Histiotoma julum*. A — larva, ventral view. B — larva, dorsal view. C — protonymph, ventral view. D — protonymph, dorsal view.

## DESCRIPTION OF PROTONYPH

*General features.* — (Plate 6). Average length 0.215 mm.; average width 0.110 mm. The larva metamorphoses into a protonymph stage with the fourth pair of legs being added. The protonymph is even more like the adult female than the larva. The gnathosoma is essentially a duplicate of the adult except for size. The setal pattern of each of the first three legs is the same as in the adult female, except as in the larva the trochanter setae *t* have not made their appearance. It is interesting that the number of setae of the fourth pair of legs is much reduced as compared with the adult. The missing setae are as follows: the femoral, the two tibial, and three of the seven terminal tarsal setae associated with the claw. The bosses and elevations noted in the larva are still present in the protonymph but are somewhat less conspicuous. The excretory pores make their appearance in the protonymph and are found in the same position as in the adult. No sculpturing, or granulation can be seen on the rostrum. Neither primary nor secondary sexual structures have made their appearance. The number, size, arrangement, and relative position of the setae of the dorsum duplicates the condition found in the adult female, except for the marginal seta *do7* which is missing. Hence, the protonymph is male-like in dorsal setal pattern. The venter of the protonymph has essentially the same pattern of setae as the adult female. However, seta *vm1* has not made its appearance, and all the setae are so small that they can be seen only after the most careful searching. This applies especially to seta *vm3* which is exceedingly minute. It will be noted that the protonymph has acquired three additional pairs of ventral setae as compared with the larva, namely: *vm3*, *vo1*, and *vo2*. Again, as in the larva, there is one pair of ringlike structures but a shift in position of these structures has taken place. These are now located on a line between coxae IV. It may be remarked at this point that the protonymph has alternative pathways to ensuing stages. It may metamorphose into the deutonymph, or migrant stage; or it may metamorphose directly into the tritonymph stage. Attention should be given also to the fact that the claws on legs III-IV are similar to that of the female rather than the male. Pit-like structures have not been seen in the protonymph.

## DESCRIPTION OF THE DEUTONYMPH

*General features.* — (Plates 7,8 ). Average length 0.193 mm.; average width 0.142 mm. The deutonymph is distinctly specialized and different from any other stage in the life cycle of an anoetid. The color is pinkish-brown instead of whitish as in the trophic form. It has heavier sclera and is shield-shaped. It is an active form which may explore all parts of its habitat, or it may lie in wait for a moving object, *e.g.*, a larger mite or an insect, to which it will firmly attach itself by a pair of

well developed suckers.

*Gnathosoma*. — The gnathosoma is vestigial as compared with the adult, or other stages. It is represented by what appears to be a pair of almost completely fused pedipalps, and the gnathosomal base is obscured from view dorsally by the overhanging rostral portion of the propodosoma. The fused pedipalps bear a pair of long flagella-like setae *pp1*, equal to length of tarsus II, and a pair of minute setae *pp2*. The mouth and associated structures are absent. At the base of the pedipalps a heavily sclerotized ring or collar can be seen.

*Venter: Propodosoma*. — The anterior limits of the propodosoma are marked by the heavily sclerotized apodemata *a1*. The posterior limits of the propodosoma are apodemata *a4*, and a continuation of this structure antero-laterad to the margin of the dorsal sulcus. Apodemata *a1* join posteriorly in the midline to form the anterior portion of the sternum *st1* which ends free. Anteriorly apodeme *a1* ends in a T-shaped chitinous bar which makes contact with the gnathosomal collar. Apodeme *a2* is also heavily chitinized and ends in a bifurcated process anteriorly and laterally. Posteriorly *a2* almost makes contact with the medial portion of apodeme *a4*. A ringlike structure *di1* lies near the anterior end of apodeme *a2* on coxa I. Apodeme *a3* is made up of a posterior portion, almost membranous-like; and an anterior process which is heavily sclerotized and lies at the lateral margin of trochanter II. The membranous portion is continuous posteriorly with apodeme *a4*. Apodeme *a4* from the point of contact with *a3* projects mesially as a heavy bar and almost makes contact with *a2*. Associated with this portion of *a4* can also be seen a faint membrane lying beneath the surface of the venter. This joins with the similar membrane from the other side to form a very faint line which almost makes contact with the middle sternum *st2*. Laterally and posteriorly *a4* ends in a heavily sclerotized process lying at the base of trochanter III. Laterad of the chitinous process of apodeme *a3* a fine seta *dm4* is seen. This ventral seta appears to correspond to the dorsally placed seta *dm4* of the female. *Metapodosoma*. — Apodeme *a5* lies at the anterior end of trochanter IV and continues mesially to join the middle sterna *st2* and *st3*. Laterally *a5* is continuous with apodeme *a6*. A ringlike structure *di2* lies on coxa III above *a5* and is equidistant from trochanter III and *st2*. Apodeme *a6* is continuous with *a5* at the anterior end of trochanter IV and proceeds posteriorly and mesially to join a Y-shaped portion of the sternum *st4*. A faint transverse line, not strong enough to be an apodeme, connects the lateral junctures of *a5* and *a6*. A conspicuous ellipsoidal ring is seen just below *st4*. Within this structure is a longitudinal depression with two very faint rings on each side. This has been called the genital opening by a number of workers. Since external genitalia do not make their appearance until the adult stage, it is doubtful that this depression represents even a vestigial genital structure. The function of

the oval structure is not known. A pair of very minute setae *vm1* are seen between the oval structure and the coxal IV discs *di3*. Posteriorly the metapodosoma is bounded by a transverse line coinciding with the anterior margin of the suctorial plate. *Opisthosoma*. — What is designated the ventral opisthosoma in the deutonymph is almost entirely made up of a large, conspicuous suctorial plate. The lateral and posterior margins of this plate are marked by very faint radial striations. Four pairs of distinct disc-like structures are found within the plate. The most anterior pair *su* are functional suckers for attachment to insects and other organisms. They can be seen in living animals under favorable conditions extended for a distance approximately two or three times their diameter. This is the only pair of functional suckers in the suctorial plate. The pair of plate discs *pd1*, just posteriad of the suckers are larger in diameter than the other discs, or the suckers. Radial striations define their borders. Laterad and posteriad of disc *pd1* are found two other pairs of distinct raised discs *pd2* and *pd3*. These discs are similar in general appearance to coxal discs *di1* and *di2*, although somewhat larger. Very faint, indefinite bodies (*b1* and *b2*) can be seen in each quadrant of the suctorial plate in marginal positions. These bodies may represent degenerate suckers, but there is no evidence for this. In the mid-line between the suckers *su* a small but fairly distinct structure *an* can be seen which is reminiscent of an anus. It is not certain that *an* is an opening, and it is chiefly because of its position that it is suggestive of an anus. It has been observed to pulsate when the suckers are distended, which may indicate that it has a hydrostatic function. In the mid-line lying between discs *pd3* and posteriad of *an* a very faint, indefinite, oblong body *b3* may be seen. At the posterior margin of the suctorial plate, seta *vo3* may be seen.

*Dorsum: Propodosoma*. — The anterior portion of the propodosoma forms a slight rostrum which partially overhangs the fused pedipalps. A definite sulcus marks the posterior limit of the propodosoma, which is smooth except for faint transverse sculpturing. Two pairs of short, fine setae *dp3* and *dp4* are seen slightly anterior of the sulcus. What appears to correspond to setae *dp1* and *dp2* of the adult and other stages, including the larva, are missing. *Metapodosoma*. — The cuticle immediately posterior to the sulcus is faintly striated transversely. The setae of the metapodosoma are fine and of equal size. They are the same length as those of the opisthosoma and slightly longer than those of the propodosoma. The pattern of the setae is somewhat similar to that of an adult. For convenience in identifying these setae, but without necessarily implying homology, they have been given numbers which correspond to setae similarly located in the female. If this scheme is followed it will be noted that seta *dm4* is in a ventral position as indicated above. A line connecting setae *dm5* marks the posterior limits of the metapodo-

soma dorsally. This boundary insures approximate correspondence of setae of the deutonymph with the setae of other stages. *Opisthosoma*. — Neither excretory pores nor pit-like structures can be detected on the dorsal surface of the opisthosoma. Again the setae have been arbitrarily labeled to more or less conform to similarly placed setae of other stages. All of the setae are equal in length. It will be noted that the number of opisthosomatic setae of the deutonymph dorsum is the same as for the protonymph, tritonymph, and male; two more than in the larva, namely *do4* and *do6*; and one less than the female *do7*.

*Legs* (Plates 7, 8). — All of the legs of the deutonymph are long, tapering and heavily sclerotized. *Leg I: Coxa*. — The coxa of leg I bears no setae in contrast with the adult female which bears one coxal seta *vp1*. *Trochanter*. — The trochanter has no definite setae, but in the same position of the trochanter seta *t* of the adult is seen what appears to be a minute spine-like process of the cuticle *t2*. On the dorsal surface there is a similar process *t1*. It will be recalled that neither these processes nor true setae can be found on the trochanter of the larva or the protonymph. *Femur*. — The femur bears one seta *f* obviously corresponding to a similar seta of the adult and all other stages. *Genu*. — The genu bears three conspicuous setae *g1*, *g2*, and *g3*. It is assumed that a seta corresponding to *g4* of the adult and all other stages is missing. *Tibia*. — The tibia bears only two setae which are assumed to be *ti1* and *ti3* in contrast with the adult and all other stages which have three setae. *Tarsus*. — A cluster of the most conspicuous setae of the tarsus *ta1*, *ta2*, and *ta3* seem to arise from the distal portion of the tibia but actually take their origin from the proximal portion of the tarsus. The club-shaped, striated sensory seta *tal* is obviously homologous with the corresponding structure of other forms. The homology or even correspondence of other setae of the tarsus is indeed most uncertain. Using as the criterion the relative position of setae, the same numbers have been used to designate apparent counterparts in the adult. On this basis setae *ta9*, *ta10*, *ta11*, *ta13*, and *ta14* are missing as compared with other stages. Attention is invited to the lancet-like seta *ta15*; to the distinctive spoon-shaped sensory seta *ta16*; the extremely long tapering seta *ta3* which is longer than tibia I. The morphology of these setae is peculiar to the deutonymph. *Leg II: Coxa*. — As in the adult and other stages no coxal setae are present in the deutonymph. *Trochanter*. — The trochanter bears two spine-like processes *t1* and *t2* similar to those found in trochanter I. *Femur*. — The femur bears one seta *f* comparable in size and position to a similar seta on femur I. *Genu*. — The number and arrangement of setae on genu II is very similar to that of genu I. The atypical seta *g3* is almost twice as long as the corresponding seta of genu I. *Tibia*. — It appears that tibia II has an additional seta as compared with tibia I, namely *ti2*. In addition there is no cluster of tarsal setae *tal-ta3* apparently inserted in the tibia.



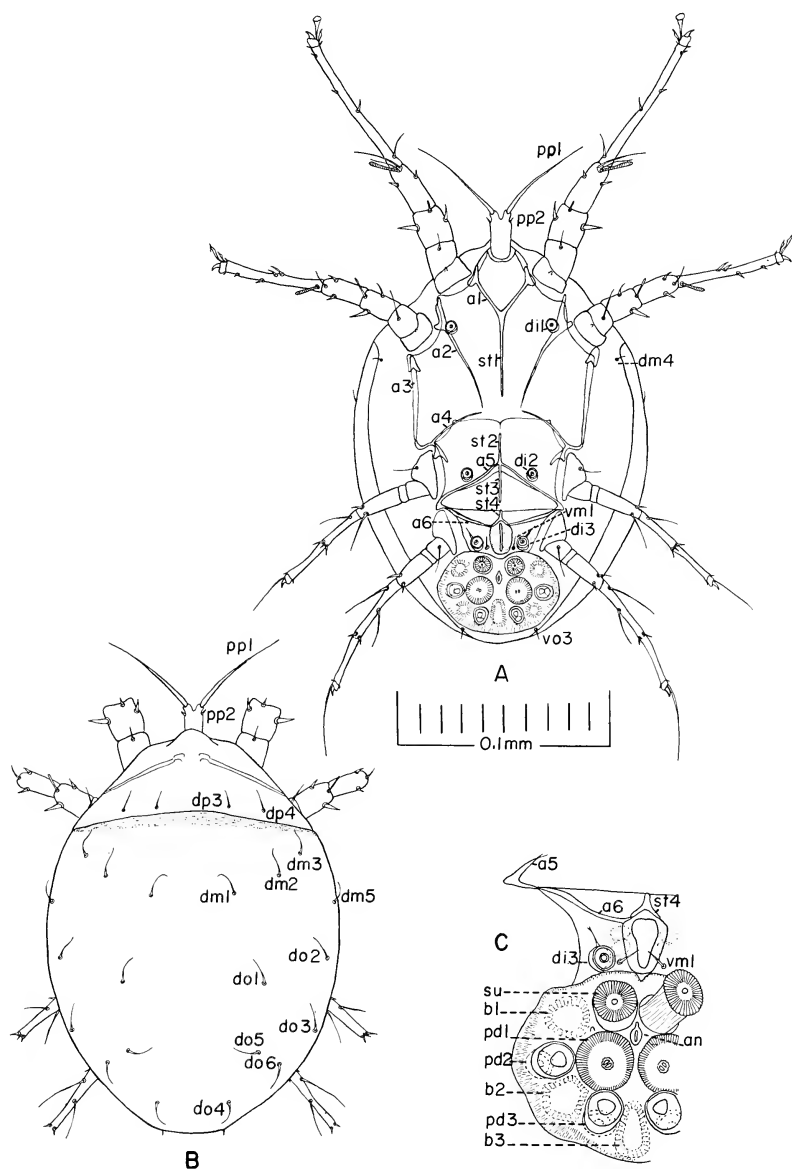


Plate 7 — *Histiostoma julorum* deutonymph. A — ventral view. B — dorsal view. C — details of suctorial plate.

*Tarsus*. — The tarsus is considerably modified as compared with tarsus I. The striated seta *ta1* is present but the atypical setae *ta2* and *ta3* associated with it in tarsus I are missing. What is assumed to be seta *ta4* has moved distally to become closely associated with seta *ta5*. Seta *ta16* is lancet-like instead of spoon-shaped as *ta16* of tarsus I. In other details tarsus II is similar to tarsus I. *Leg. III: Coxa*. — No setae can be seen on coxa III. *Trochanter*. — The trochanter bears one long seta *t* comparable in type and position to the trochanter seta of the adult. *Femur*. — As in other stages the femur of leg III bears no setae. *Genu*. — What is assumed to represent the genu of leg III is reduced to approximately one-fourth the length of genu I or II, and is devoid of setae. *Tibia*. — Two setae are present as in tibia III of the adult. These are found at the distal end, one *ti1* which is spine-like and the other *ti3* much longer and finer. The separation of the tibia from the tarsus is by a very indistinct line just distal to setae *ti1* and *ti3*. *Tarsus*. — This is peculiar in that it appears to be segmented. A cluster of three small setae *ta5*, *ta6*, and *ta7* is found at the distal end of the first incipient segment. A long hairlike seta *ta4*, assumed to correspond to seta *ta4* in the adult is seen in the proximal portion of this first segment. A striking difference between tarsus II and III is that in the latter seta *ta15* is missing. Also *ta16* is long and tapering instead of lancet-shaped as in tarsus II. *Leg IV: Coxa*. — The coxa of leg IV bears one seta *vm1*. *Trochanter*. — This is similar in shape and size to trochanter III, but bears no setae. *Femur*. — The femur bears one seta *f* similar in shape and size to seta *t* of trochanter III. *Genu*. — This is in all respects similar to genu III. *Tibia*. — This bears two setae *ti1* and *ti3* corresponding to similar setae on tibia III. Seta *ti3* of tibia III is about twice as long as *ti3* of tibia IV. *Tarsus*. — The tarsus also appears to be segmented, but this is by no means certain. The number of setae is the same as for tarsus III but there are distinct differences in size and arrangement. What are arbitrarily assumed to correspond to setae *ta4* and *ta7* of tarsus III are much longer, and *ta7* has shifted to a more proximal position. Seta *ta16* is about twice as long as the corresponding seta of tarsus III.

#### DESCRIPTION OF TRITONYMPH

*General features* (Plate 9). — Average length 0.218 mm.; average width 0.125 mm. In general the tritonymph is very similar in appearance to a non-gravid female. The type, arrangement, and relative size of the setae are precisely the same as for the female, including trochanteral setae of legs I-III, and the femoral, tibial, and tarsal setae of the leg IV, which latter are missing in the protonymph. The setal pattern for the remainder of the body is the same as for the female, except one pair of opisthosomatic setae, assumed to correspond to *do7* of the female is not present. It

will be recalled that this is the condition existing in the protonymph, and therefore, with respect to the dorsal setae pattern these two stages are similar to the male. Again no sculpturing or granulation can be seen on the rostrum. The bosses and elevations noted in the protonymph and larva can also be seen in the tritonymph but are not quite so prominent.

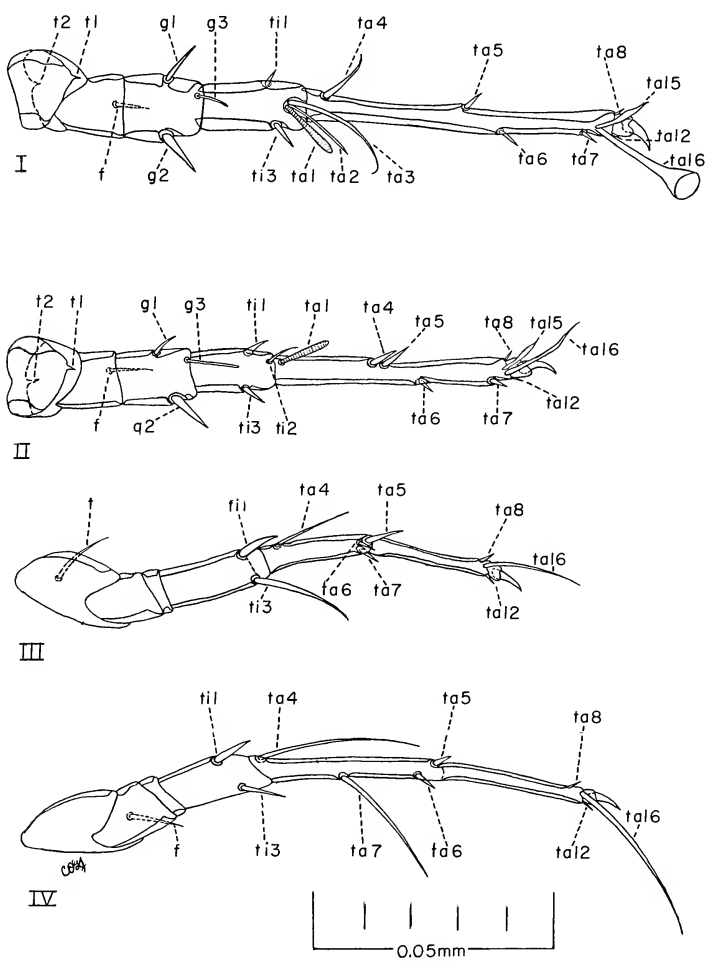


Plate 8 — *Histiostoma julorum* deutonymph. Dorsal view of legs.

It will be noted that metapodosomal seta *uml* has now made its appearance. Two pairs of ring-like structures can be seen in the tritonymph, but their position is different from the position of similar structures in the male or the female. These ringlike structures tend to lie between coxae IV. It will be noted also that the claws of legs III and IV are female-like as in the protonymph. Of special interest is the lack of excretory pores. It is not understood why these structures, which make their appearance in the protonymph, disappear in the tritonymph and reappear in the adult. Pit-like structures cannot be seen in the tritonymph. Neither primary nor secondary sex structures have made their appearance at this stage.

*Variations in H. julorum.* — Two interesting and distinctly different "varieties" of this species have been collected, one of them three times in different localities. We are tentatively taking the position that these "varieties" are not sufficiently distinct to be classified as true taxonomic varieties or sub-species of the "type variety" described above. Planned cross-breeding experiments should throw light on this question. Both of these "varieties" breed true and differ from each other and the "type variety" in a number of features, the more useful of which for identification purposes in the male are as follows: (Plates 9, 10, 12). "type variety" — claws III-IV serrated; no outstanding hysterosomal elevations or enlarged setae bases; "bursoid variety" — distinct dorsal median elevation on the hysterosoma resembling a bursa copulatrix; claws III-IV not serrated; "2-boss variety" — setae *dol* closer together mounted on slight but distinct elevations; claws III-IV not serrated.

*Comparison of females* (Plates 11, 12). — Only very minor differences among the females of the three "varieties" have been noted. Tarsus I of "bursoid" is slightly heavier than "type" and "2-boss" and the mid-tarsal setae are closely grouped. Tarsus II is essentially the same for each "variety." Tarsus III seta *ta9* of "2-boss" longer, and seta *ta7* of "bursoid" longer and heavier than other "varieties." Seta *ta9* tarsus IV of "2-boss" slightly longer than other "varieties." The structure of the bursa copulatrix for each "variety" is different. If our interpretation of these minute organs is correct the morphology of the bursa copulatrix of each "variety" most closely matches the male genitalia of its own "variety." For example, the penial seta of the "type" is directed posteriorly and thus matches the posteriorly directed bursa copulatrix orifice. Other small differences in the morphology of the bursa copulatrix and the corresponding differences in the male genitalia suggest an incipient or actual sexual isolation mechanism in these "varieties."

*Comparison of males* (Plates 9, 10, 12). — In addition to the differences in the males of the three "varieties" referred to above, the males also differ in a number of other characters. The ringlike structures, al-

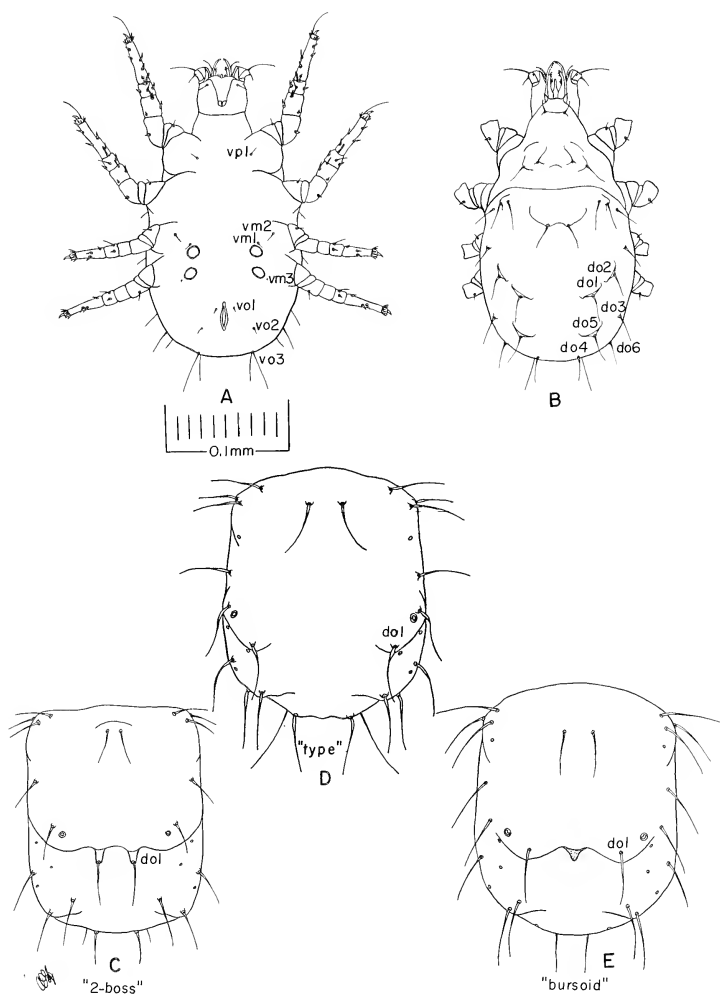


Plate 9 — *Histiotostoma julorum*. A — tritonymph, ventral view. B — tritonymph, dorsal view. C, D, E — males, dorsal hysterosoma of the three "varieties" — "type," "bursoid," and "2-boss."

though somewhat variable in size, shape, and position even among individuals of the same "variety" are typically as shown in Plate 12. Seta *vm3* is posteriad and laterad of *r2* in "type," but is more anterior in position in "2-boss" and "bursoid." Seta *vol1* in "2-boss" is very close to the

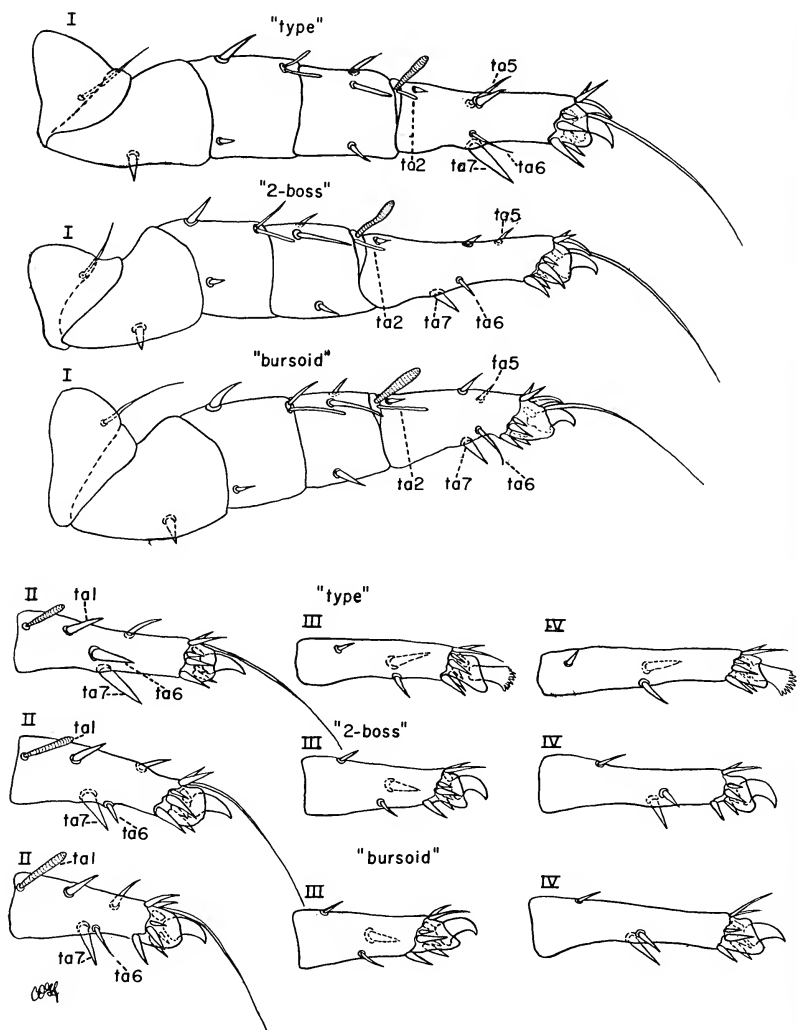


Plate 10 — *Histiotoma julorum* males. Dorsal view of legs I, and tarsi II-IV of the three "varieties" — "type," "2-boss," and "bursoid."

posterior margin of the external genitalia in comparison with the other two "varieties." Seta *vo2* is laterad of the posterior end of the anus in "type" and "2-boss" and laterad of the anus in "bursoid." The "variety bursoid" has a distinct genital plate with *vo3* located on its posterior margin. "Varieties 2-boss" and "type" are without a genital plate, and *vo3* is located more posteriorly. The legs of the three "varieties" differ in a number of definite features. Mid-tarsal setae leg I of "type" are more closely grouped, *ta5* longer, *ta7* stouter than "2-boss" and "bursoid." "Bursoid" has a short tarsus I with *ta2* nearly equal to *ta1*; *ta6* of "2-boss" shorter than *ta6* of "bursoid" and "type." Leg II tarsus seta *ta6* of

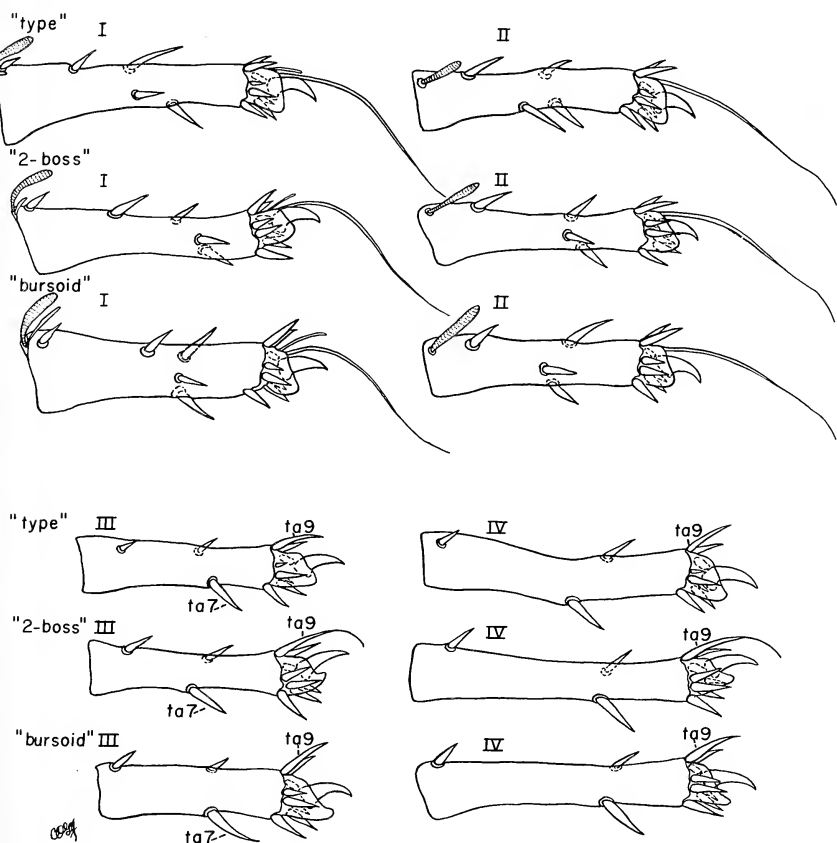


Plate 11 — *Histiostoma julum* females. Dorsal view of the tarsi I-IV of the three "varieties" — "type," "2-boss," and "bursoid."

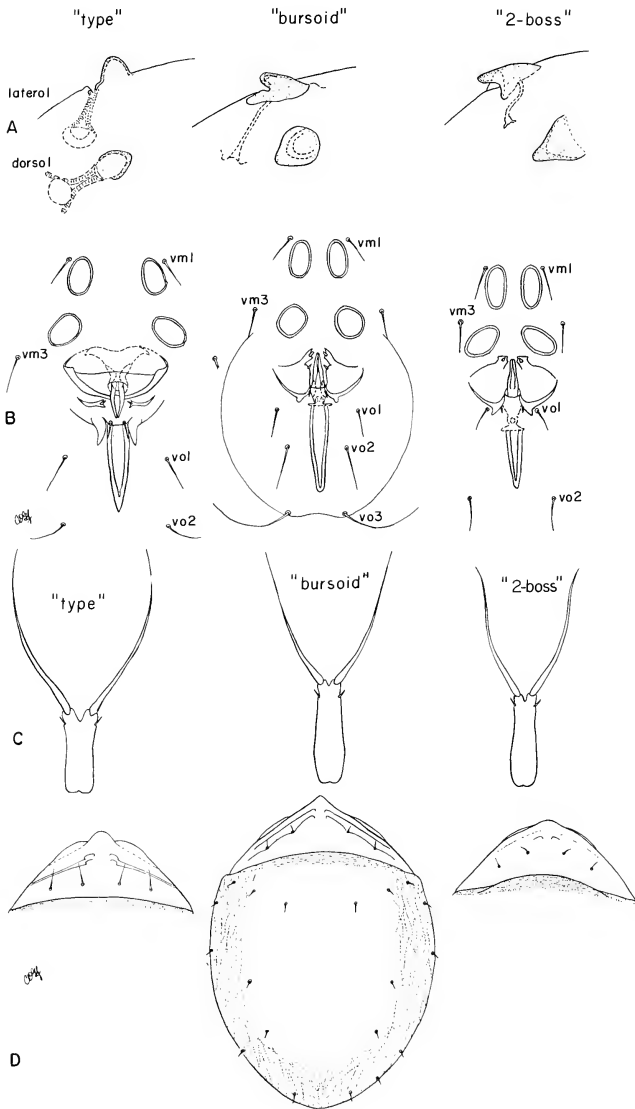


Plate 12 — *Histiotoma julorum* "varieties" — "type," "bursoid," and "2-boss." A — bursa copulatrix. B — external male genitalia. C — deutonymph, fused pedipalps and setae. D — deutonymph, propodosoma or dorsum.



"type" nearly equal to *ta*7; "2-boss" *ta*6 smaller than *ta*7; "bursoid" *ta*6 nearly equal but finer than *ta*7; seta *ta*1 leg II smallest in "type," largest in "bursoid." Legs III-IV are very similar in all three "varieties" except for the serrated claws of "type."

*Comparison of deutonymphs.* — (Plate 12). The deutonymphs of all "varieties" are very similar. The fused pedipalps of "type" are broader and shorter, and the propodosomal setae distinctly longer in "type" than in "bursoid" or "2-boss." The margins of the hysterosoma are faintly sculptured in "bursoid," and there are minor differences in transverse sculpturing and striations.

### BIOLOGY

*Habitat.* — Although *H. julorum* has been collected by the methods described above in a variety of situations, trophic forms have been seen only in niches which contain moist decaying organic matter. Collections made in lawns, pine woods, and other relatively dry areas can be accounted for by the trapping of insects and other arthropods which are infested with deutonymphs. In a suitable culture medium, or when they find themselves in a suitable natural habitat, the deutonymphs will metamorphose into the trophic forms, and in this manner establish a new colony.

*Culture.* — As judged from the variety of niches in which this species has been collected, and through observations made in the laboratory, it appears that almost any type of decaying organic matter will serve as a culture medium. Both the house fly and fruit fly media described above support thriving colonies. It is essential that the medium be moist since, as for most anoetids, they prefer to wade in a thin film of water. This probably facilitates movement and hence makes an abundant food supply accessible. They appear to be continuous and non-specific feeders when observed under a microscope. Although no extended experiments have been undertaken to determine nutrient requirements or preferences for members of this species, it appears that yeasts and other microorganisms form their main diet. Culture technique for this species is the same as for most other anoetids and is described above.

*Life cycle.* — Under optimum conditions of culture at room temperature, only six days is necessary for completion of the life cycle of *H. julorum*. This period apparently can be lengthened indefinitely under crowded conditions. The sequence of stages is as follows: egg — larva — protonymph — tritonymph — adult, or egg — larva — protonymph — deutonymph — tritonymph — adult. Each of these stages is distinct morphologically, and is described above in detail. The surprising observation that a protonymph may take alternative pathways to reach the adult stage *i. e.*, it may omit the deutonymph — is commented on below. This was determin-

ed by observing protonymphs in the quiescent state. In some of these fully formed tritonymphs could be seen. In others fully formed deutonymphs could be observed. The period of time required for each developmental stage has not been determined accurately. They appear to be roughly equal when the entire cycle is completed in six days. It has been noted, however, that eggs vary greatly in their degree of development at the time of oviposition, from the blastula stage at one extreme to a fully formed larval stage at the other. Except for the deutonymph, it appears that each stage progresses to the next without interruption, when the food supply is adequate, with a quiescent period in between each stage. In the case of the deutonymphs it has been observed that some deutonymphs will metamorphose into tritonymphs in a matter of hours, while others under apparently the same conditions will remain in the deutonymph stage for as long as several weeks. The ability of the deutonymph to delay or vary the time of onset of metamorphosis, like its many other adaptive features, is befitting to its role as a dispersal stage of the species, but nothing is known at present about what conditions or mechanisms trigger metamorphosis.

Every developmental stage, including the adult, shows very considerable size variation. This is true even when the specimens measured come from inbred strains and are cultured under the same conditions. Plate 13 gives the results of a series of measurements on individuals selected at random from inbred stock cultures. All measurements were made on specimens mounted in Hoyer's medium. It will be noted that individuals of some stages may be as much as twice the length of other individuals of the same stage and, moreover, that there is much overlap between different stages. The variation in length is assumed to be due primarily to small chance differences in consumed nutrients because of localized crowding partial dessication of the culture medium, and other conditions. It is obvious from the above that caution must be exercised in using size as a criterion for determination of species.

*H. julorum* exhibits male parthenogenesis. Careful observations have shown that isolated virgin females produce only male offspring. Fertilized eggs give rise to females.

That ringlike structures in the anoetids may actually be vestigial suckers, is strengthened by the following observations. The larvae of both the Acaridae and Anoetidae typically have a single pair of ringlike structures or suckers located posterior to the first pair of legs; in the protonymphs of both families a single pair of ringlike structures are present but now displaced to the opisthosoma; likewise a parallelism of these structures exists in the tritonymph where two pairs of suckers or ringlike structures are found. Further correspondence in position of these structures occurs in the adult. However, it must be noted that in no described

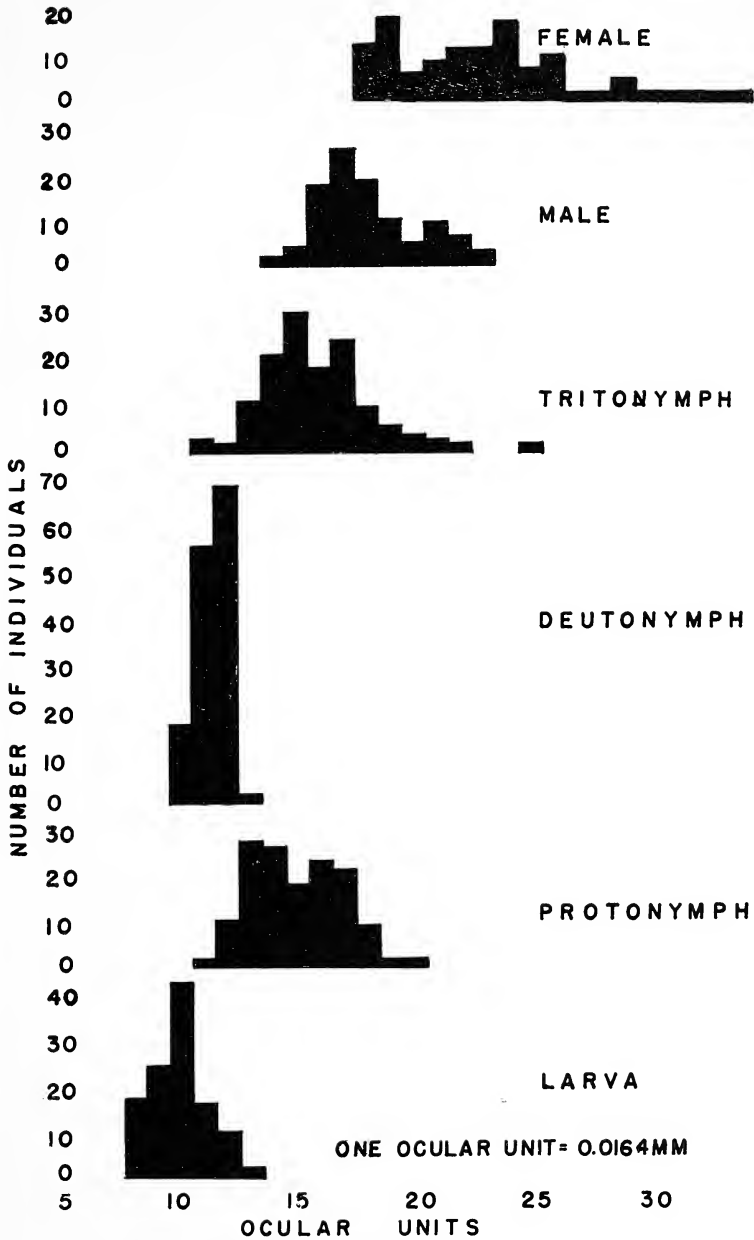


Plate 13 — *Histiostoma julorum* — size range of various stages.

species of the Anoeidae is there any evidence that these ringlike structures function as suckers.

*Collections.* — Random and sporadic collecting trips have yielded the following results:

"type variety"		
DATE	LOCATION	COLLECTOR
Sept. 1950	Wooded area 9 miles west of Richmond, Va.	R. D. Hughes
Oct. 1950	Wooded area near Bluefield, W. Va.	G. S. Foresman
Oct. 1950	Compost 10 miles north of Richmond, Va.	R. D. Hughes
Oct. 1950	Wooded area 8 miles west of Richmond, Va.	C. O. Goode
Nov. 1950	Wooded area 9 miles west of Richmond, Va.	R. D. Hughes
Aug. 1951	Pine woods near Norris Dam, Tenn.	R. D. Hughes
Oct. 1951	Pear orchard 8 miles east of Richmond, Va.	R. D. Hughes
Oct. 1951	Chickahominy Swamp near Ellerson, Va.	R. D. Hughes
Dec. 1951	In orange grove, Lantana, Fla.	Mr. Blood
May 1952	Near Appomattox River, Colonial Heights, Va.	J. B. Williams
June 1952	Damp woods near Victoria, Va.	A. E. Glover
June 1952	Wooded area near Vernon Hill, Va.	F. C. McDowell
June 1952	Wooded area near Hackettstown, N. J.	R. L. Shevitz
June 1952	Compost heap near Valley Stream, N. Y.	C. E. Bingley, Jr.
June 1952	Swamp near Woodlawn, Va.	R. D. Jones
June 1952	Old apple orchard near Covington, Va.	E. F. Kohne
Oct. 1952	Shady lawn in Ellerson, Va.	R. D. Hughes

DATE	LOCATION	COLLECTOR
Aug. 1953	Chickahominy Swamp near Ellerson, Va.	R. D. Hughes
June 1954	Cone River area near Warsaw, Va.	A. H. O'Bier
Sept. 1955	Pine woods near Mechanicsville, Va.	F. A. Robertson
Sept. 1955	Under grapevine near Ellerson, Va.	R. D. Hughes
"2-boss variety"		
June, 1954	Near Warsaw, Va.	A. H. O'Bier
Oct. 1954	North of River Road 9 miles west of Richmond, Va.	F. A. Robertson
"bursoid variety"		
June 1954	Near Warsaw, Va.	A. H. O'Bier

In addition to the above recent collections from eastern United States it has been reported also from Europe, as follows:

- 1841 Germany; on *Julus unilineatus* (*Hypopus julorum* Koch) C. L. Koch  
 1844 On *Julus* (*Hypopus ovalis* Gervais) Gervais  
 1849 On insects (*Hypopus vulpis* Dujardin) Dujardin  
 1886 Italy; in organic matter, deutonymph on *Julus mediterraneus* (*Hypopus julorum* Koch) A. Berlese  
 1888 Venice; in organic matter on *Julus mediterraneus* (*Histiostoma julorum* Koch) C. Canestrini  
 1905 Sumatra; on *Sphaeridium dimidiatum* Cast. C. Fisher  
 (*Histiostoma sumatrensis* Oudemans)

*Types.* — Holotype no record. Plesiotypes (supplied by present authors) located as follows:

- U. S. National Museum, Washington, D. C.  
 British Museum of Natural History, London, England  
 Rijksmuseum van Natuurlijke Historie, Leiden, Netherlands  
 Museum National d'Histoire Naturelle, Paris, France  
 The South Australian Museum, Adelaide, South Australia  
 Natal Museum, Pietermaritzburg, Union of South Africa

National Collection, Ottawa, Canada

USSR Academy of Science, Moscow and Leningrad, USSR

Musee Royal d'Histoire Naturelle de Belgique, Brussels, Belgium

# KEY TO THE SPECIES OF THE GENUS *Histiostoma* BASED ON FEMALES

1. A terminal tarsal seta, legs I-IV, flagella-like ..... 2  
     A terminal tarsal seta, legs I-II only flagella-like ..... 6
2. Dorsal hysterosoma heavily shagreened and with distinct  
     bosses ..... *H. protuberans*, sp. nov.  
     Dorsal hysterosoma not shagreened and without distinct bosses ..... 3
3. Anterior and posterior ringlike structure *r1* and *r2* circular,  
     or almost circular ..... 4  
     Posterior ringlike structures oval or elongated ..... 5
4. A terminal tarsal seta leg IV longer than tarsus IV .... *H. pyriforme*  
     Longest terminal tarsal seta, leg IV, shorter than tarsus IV. *H. berghi*
5. Pedipalpal seta *pp1* spine-like and anteriorly directed; seta  
     *vm3* posterior to posterior ringlike structure *r2* — *H. sextoni*, sp. nov.  
     Pedipalpal seta *pp1* flagella-like and laterally directed; seta  
     *vm3*, mesiad of posterior ringlike structure *r2* ..... *H. cyrtandrae*
6. Setae on dorsum pilose ..... *H. piloseta*, sp. nov.  
     Setae on dorsum not pilose ..... 7
7. Chelicera ending with minute seta with terminal knob; pedipalp  
     with many bristle-like projections distally and laterally *H. bakeri*, sp.  
     nov. Without knobbed seta, or without seta on end of chelicera;  
     without bristle-like projections associated with the pedipalp ..... 8
8. Posterior end of posterior disc *r2* on level with anterior end of  
     anus ..... *H. himalayae*  
     Posterior end of posterior disc *r2* distinctly anterior to anus ..... 9
9. Posterior disc *r2* ovate, or elongate ..... 10  
     Posterior disc *r2* circular, or almost circular ..... 13
10. Seta *vm3* laterad of and on a level with posterior disc *r2*  
     ..... *H. fimetarium*  
     Seta *vm3* not laterad of posterior ventral disc *r2* ..... 11
11. Tarsal seta *ta5* legs III-IV ending in distinct hook,  
     or barb ..... *H. phyllophorus*

Tarsal seta <i>ta5</i> legs III-IV without hook or barb .....	12
12. Cheliceral flagella equal to or longer than serrated portion of chelicera; seta <i>vm3</i> mesiad of and opposite posterior disc <i>r2</i> .....	<i>H. humiditatis</i>
Cheliceral flagella shorter than serrated portion of chelicera; seta <i>vm3</i> posterior to or near end of posterior disc <i>r2</i> .....	<i>H. nigrellii</i> , sp. nov.
13. Pedipalpal seta <i>pp2</i> apparently missing; posterior disc <i>r2</i> on a line between coxa II and III .....	<i>H. murchiei</i> , sp. nov.
Pedipalpal seta <i>pp2</i> present; posterior disc <i>r2</i> not on a line between coxa II and III .....	14
14. Pedipalpal seta <i>pp1</i> spine-like and nearly equal to seta <i>pp2</i> .....	<i>H. feroniarum</i>
Pedipalpal seta <i>pp1</i> flagella-like and over twice as long as <i>pp2</i> .....	15
15. Chelicera not serrated; seta <i>vm3</i> below and laterad of posterior ventral disc <i>r2</i> .....	<i>H. gordius</i>
Chelicera serrated; seta <i>vm3</i> below and laterad of posterior ventral disc <i>r2</i> .....	<i>H. julorum</i>

KEY TO THE SPECIES OF THE GENUS *Histiostoma* BASED  
ON MALES

1. A terminal tarsal seta, legs I-IV, flagella-like; distinctly longer than claw .....	2
Only terminal tarsal seta on legs I-II flagella-like and distinctly longer than claw .....	6
2. A terminal tarsal seta legs I-IV nearly equal in length, as long or longer than tarsus .....	<i>H. pyriforme</i>
Longest terminal tarsal seta legs III-IV, shorter than tarsus IV. ....	3
3. Dorsal hysterosoma heavily shagreened, giving a sculptured effect .....	5
Dorsal hysterosoma not shagreened .....	4
4. Both anterior and posterior discs <i>r1</i> and <i>r2</i> lie close together and directly anterior to external genitalia .....	<i>H. berghi</i>
Posteriorly pair of discs <i>r2</i> widely separated and do not lie directly above external genitalia .....	<i>H. sextoni</i> , sp. nov.
5. Dorsal hysterosomal setae long, flagella-like, distinctly longer than tarsus IV .....	<i>H. phyllophorus</i>
Dorsal hysterosomal setae medium in length; shorter than tarsus IV .....	<i>H. protuberans</i> , sp. nov.

6. Both anterior and posterior pair of discs *r1* and *r2* lie close together and directly anterior to genitalia ..... 7  
     Posterior pair of discs *r2* widely separated and do not lie directly above genitalia ..... 9
7. Dorsal hysterosomal setae as long or longer than genu I ..... 8  
     Dorsal hysterosomal setae minute; distinctly shorter than genu I ..... *H. murchiei*, sp. nov.
8. Pedipalpal seta *pp1* over twice length of *pp2* ..... *H. julorum*  
     Pedipalpal seta *pp1* and *pp2* nearly equal ..... *H. feroniarum*
9. Both anterior and posterior pair of discs *r1* and *r2* distinctly elongated ..... *H. nigrellii*, sp. nov.  
     Either or both anterior and posterior pair of discs *r1* and *r2* distinctly round ..... 10
10. Pedipalpal seta *pp1* distinctly shorter than *pp2* ..... *H. himalayae*  
     Pedipalpal seta *pp1* distinctly longer than *pp2* ..... 11
11. Ventral seta *vm3* laterad of posterior disc ..... *H. fimetarium*  
     Ventral seta *vm3* mesiad of posterior disc ..... 12
12. Dorsal hysterosoma heavily shagreened, giving a sculptured effect ..... *H. gordius*  
     Dorsal hysterosoma smooth ..... *H. piloseta*, sp. nov.

#### KEY TO THE SPECIES OF THE GENUS *Histiostoma* BASED ON DEUTONYMPHS

1. Dorsum partially or completely shagreened, pitted, or granular .... 2  
     Dorsum smooth, or very faintly sculptured or striated, not granular ..... 9
2. Dorsal setae minute, hairlike, and equal .... *H. protuberans*, sp. nov.  
     Dorsal setae not minute, hairlike, or equal ..... 3
3. Anterior margin of hysterosoma transversely striated dorsally .... 4  
     Anterior margin of hysterosoma not transversely striated dorsally ..... 7
4. Dorsal hysterosomal setae distinctly long and equal, except dorsal opisthosomatic setae *do4* and *do6* which are short and hairlike ..... *H. gordius*  
     Dorsal hysterosomal setae not as above ..... 5
5. Two or three pairs of long, conspicuous, lancet-like setae



- on hysterosoma ..... 6  
Hysterosoma without lancet-like setae; *dm1* as long as *pp1* *H. lorentzi*
6. Hysterosomal seta *dm1* short and peg-like ..... *H. tienhoveni*  
Hysterosomal seta *dm1* long and lancet-like ..... *H. spinitarsus*
7. Only one pair of dorsal hysterosomal seta *do1* long and lancet-shaped ..... *H. ensifer*  
Three or more pairs of dorsal hysterosomal setae long and saber-like 8
8. Only three pairs of dorsal hysterosomal setae long and saber-like ..... *H. lanceocrinus*  
More than three pairs of dorsal hysterosomal setae long and saber-like ..... *H. gladiger*
9. Anterior margin of dorsal hysterosoma transversely striated ..... 10  
Anterior margin of dorsal hysterosoma not transversely striated .... 20
10. Majority of dorsal setae longer than tibia I ..... 11  
No dorsal setae as long as tibia I ..... 13
11. Soma conspicuously pear-shaped; fused pedipalps projecting distinctly beyond propodosoma ..... *H. fimetarium*  
Soma pear-shaped; fused pedipalps not projecting, or barely projecting beyond propodosoma ..... 12
12. Sternum *st1* continuous with sternum *st2* ..... *H. phyllophorus*  
Sternum *st1* not continuous with sternum *st2* ..... *H. himalayae*
13. Most dorsal setae medium in length, as long or nearly as long as genu I, but shorter than tibia I ..... 14  
All dorsal setae extremely minute, shorter than genu I ..... 16
14. Leg III seta *tal6* spatulate; sternum *st3* expanded posteriorly ..... *H. cyrtandrae*  
Leg III seta *tal6* tapering; sternum *st3* thin and not expanded .... 15
15. Dorsal propodosoma with three transverse striations, giving sculptured effect; pedipalpal setae *pp1* fine, approximately equal in length to fused pedipalps ..... *H. sextoni*, sp. nov.  
Dorsal propodosoma with two transverse striations; pedipalpal setae *pp1* much longer than fused pedipalps ..... *H. julorum*
16. Propodosoma without transverse striations; sternum *st1* continuous with apodemata *a4* ..... 17  
Propodosoma with transverse striations, giving sculptured effect; sternum *st1* not continuous with apodemata *a4* ..... 18
17. Sternum *st2* continuous with apodemata *a4* and *a5* and with faint rounded expansion in middle ..... *H. polaki*

- Sternum *st2* not continuous with apdoemata *a4* and *a5* and without expansion in middle ..... *H. polypori*
18. Fused pedipalps equal in length or shorter than genu I ..... *H. feroniarum*  
Fused pedipalps longer than genu I ..... 19
19. Apodemata *a4* not continuous in midline; *st3* and *st4* not contiguous ..... *H. humiditatis*  
Apodemata *a4* faintly continuous in midline; sternum *st3* and *st4* not contiguous ..... *H. bakeri*, sp. nov.
20. Tapering membranous claw base ..... *H. piloseta* sp. nov.  
Claw base not tapering ..... 21
21. Dorsal setae unequal in length ..... 22  
Dorsal setae approximately equal in length ..... 26
22. All dorsal hysterosomal setae minute; distinctly shorter than propodosomal setae ..... *H. crassipes*  
All dorsal hysterosomal setae not minute; not equal in length .... 23
23. Dorsal setae medium in length, and nearly equal except setae *do3*, *do4*, and *do6* ..... *H. trichophorus*  
Dorsal setae not all medium in length; size and length variable 24
24. Propodosomal seta *dp4* over twice as long as *dp3* ..... *H. cirratus*  
Propodosomal seta *dp4* shorter than or equal to *dp3* ..... 25
25. Pedipalpal seta *pp1* almost twice as long as tibia I .... *H. prodectoris*  
Pedipalpal setae *pp1* approximately same length as tibia I  
*H. murchiei*, sp. nov.
26. Seta *tal6* leg IV longer than entire leg IV ..... *H. neglectus*  
Seta *tal6* leg IV not as long as leg IV ..... 27
27. Seta *tal6* leg IV distinctly broad and saber-like *H. banjuwangicus*  
Seta *tal6* leg IV not broad and saber-like ..... 28
28. Fused pedipalps expanded, not equal in width throughout ..... 29  
Fused pedipalps not expanded, equal in width throughout ..... 30
29. Fused pedipalps broad at base, distinctly tapering anteriorly  
*H. indicus*  
Fused pedipalps broader in middle, tapering anteriorly and posteriorly ..... *H. toxopei*
30. Anterior margin of dorsal hysterosoma distinctly scalloped ..... *H. crenulatus*  
Anterior margin of hysterosoma not scalloped ..... 31
31. Tarsus I shorter than combined length of other leg segments

1958]	A REVIEW OF THE FAMILY ANOETIDAE ( <i>Acari</i> )	45
	excluding coxa .....	38
	Tarsus I equal or longer than combined length of other leg	
	segments excluding coxa .....	32
32.	Seta <i>tal6</i> leg III ends in small but distinct knob .....	<i>H. campanula</i>
	Seta <i>tal6</i> leg III not ending in knob .....	33
33.	Sterna <i>st1</i> , <i>st2</i> , and <i>st3</i> faintly continuous; apodemata <i>a4</i>	
	distinctly arched .....	<i>H. longipes</i>
	Sterna <i>st1</i> , <i>st2</i> and <i>st3</i> not continuous; apodemata <i>a4</i> not	
	distinctly arched .....	34
34.	Apodeme <i>a2</i> making contact with <i>a4</i> .....	<i>H. maritimus</i>
	Apodeme <i>a2</i> not making contact with <i>a4</i> .....	35
35.	Apodemata <i>a4</i> not continuous in mid-region .....	<i>H. insularis</i>
	Apodemata <i>a4</i> continuous in mid-region .....	36
36.	Sternum <i>st2</i> not continuous with apodemata <i>a4</i> .....	37
	Sternum <i>st2</i> continuous with apodemata <i>a4</i> .....	<i>H. litoralis</i>
37.	Dorsal propodosoma with single anterior striation; seta <i>tal6</i> leg	
	II distinctly spoon-like .....	<i>H. sapromyzarium</i>
	Dorsal propodosoma without single anterior striation; seta <i>tal6</i> leg II	
	flagellum-like .....	<i>H. berghi</i>
38.	Tarsus I twice length of pedipalpal setae <i>pp1</i> .....	<i>H. prophthalmi</i>
	Tarsus I only slightly longer than pedipalpal seta <i>pp1</i> .....	<i>H. brevimanus</i>

#### GENUS *Histiostoma* Kramer, 1876

*Diagnosis of genus.* — Diagnosis is based on the deutonymph. Coxa I with disc *di1*; coxa III with disc *di2*; coxa IV with minute seta *vm1* mesiad of disc *di3*; suctorial plate with 2 functional suckers, 2 large central discs, and 4 discs posteriorly and laterally.

*Type.* — *Histiostoma feroniarum* (Dufour), 1839.

*Histiostoma bakeri* sp. nov.

(Plates 14, 15)

*Female.* — (Plate 14). Length 0.410 mm.; width 0.225 mm. *Venter.*—Chelicera serrated, bearing 7 large teeth proximally, approximately 7 minute teeth distally, and ending in a fine process bearing a distinct knob. Cheliceral flagellum nearly twice as long as toothed portion. Seta *pp1* three times as long as *pp2*. Pedipalp bears extremely fine bristles

distally on membranous structure. Posterior ringlike structure *r2* distally elongated, nearly shoe-shaped. Setae generally shorter than in *H. julorum*. Seta *vm3* lateral to posterior ringlike structure; *vo3* slightly longer than *vo2*; *vo1* minute. *Dorsum*. — Dorsum finely granular, and sometimes

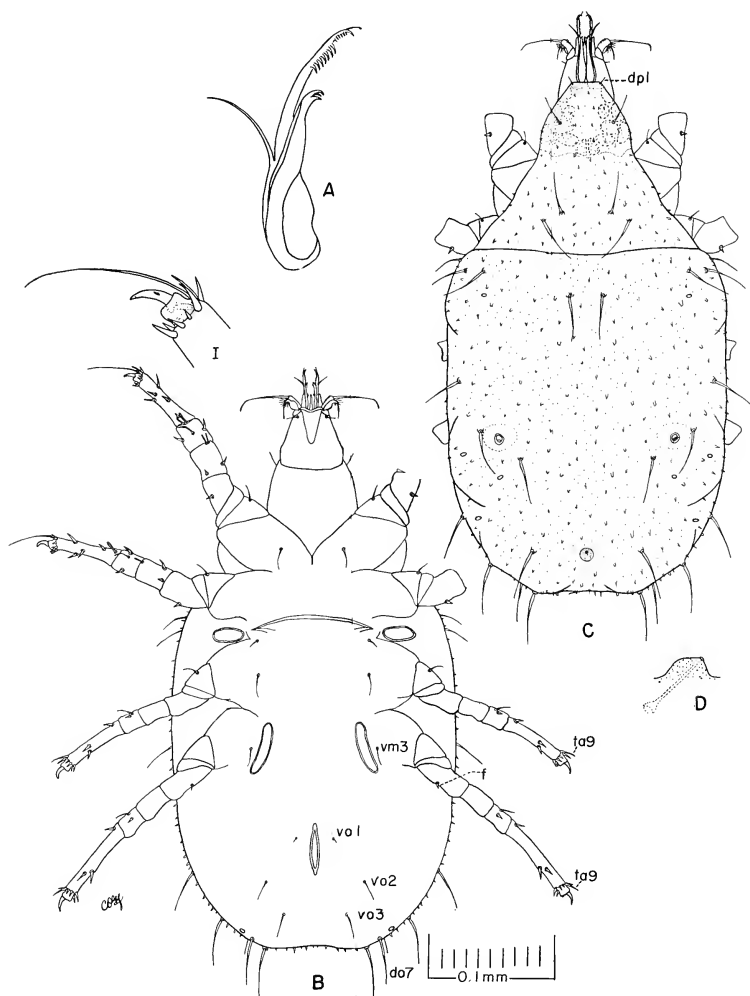


Plate 14 — *Histiotoma bakeri* sp. nov. female. A — chelicera. B — venter. C — dorsum. D — bursa copulatrix.

with minute pointed projections appearing to be cuticular in origin, which vary in number and distribution. These projections give a fuzzy appearance. Rostrum is faintly sculptured. Seta *dpl* minute; other setae similar to those of *H. julorum*. Bursa copulatrix distinctly raised, heavily granular, and with minute anterior opening. *Legs.* — Leg shape, setae size and arrangement are generally similar to *H. julorum*. Outstanding differences are the short, spine-like femoral seta of leg IV, and the slightly longer terminal tarsal setae *ta9* of legs III-IV of *H. bakeri*.

*Male.* — This species is thelytokous.

*Deutonymph.* — (Plate 15). Length 0.174 mm.; width 0.120 mm. *Venter.* — Fused pedipalps slightly longer than tibia I; seta *ppl* nearly equal in length to tarsus II. Sternum *st1* free; apodemata *a2* join *a4* which latter are faintly continuous in midline; sternum *st2* not united with *a4*, and *st3* and *st4* contiguous. By comparison with *H. julorum* discs *pd1* are smaller. *Dorsum.* — Dorsum smooth except for single line of sculpturing on the anterior propodosoma, and faint transverse striations on the anterior margin of the hysterosoma. Setae minute, hairlike, and equal in length. *Legs.* — Seta *ta16* leg I nearly cup-shaped; *ta16* leg II lancet-shaped; *ta16* leg III tapering. Seta *ta3* leg I over one-half as long as tarsus I; *ta4* longer than *ta1*.

*Remarks.* — The combination of adult characteristics most useful in identifying this species is length of seta *ppl*; the minute terminal knob on the chelicera; presence of pedipalpal bristles; elongated posterior ring-like structures; seta *vm3* laterad of *r2*. The deutonymph is very similar to that of *H. feroniarum* and *H. humiditatis* and can be distinguished from these only with difficulty (see key). This species is named in honor of Dr. Edward W. Baker.

*Collections.* — Collected by R. D. Hughes at Norris Dam, Tenn., July 1951; by Ronald D. Jones in swamp near rotting logs, Woodlawn, Va., June 1952; by R. D. Hughes in dung near Ellerson, Va., Sept. 1954; by A. H. O'Bier north of River Road, 9 miles west of Richmond, Va., Sept. 1954.

*Types.* — Holotype female and paratypes in U. S. National Museum, Washington, D. C. Paratypes located as follows:

U. S. National Museum, Washington, D. C.

British Museum of Natural History, London, England.

Rijksmuseum van Natuurlijke Historie, Leiden, Netherlands

Museum National d'Histoire Naturelle, Paris, France

The South Australian Museum, Adelaide, South Australia

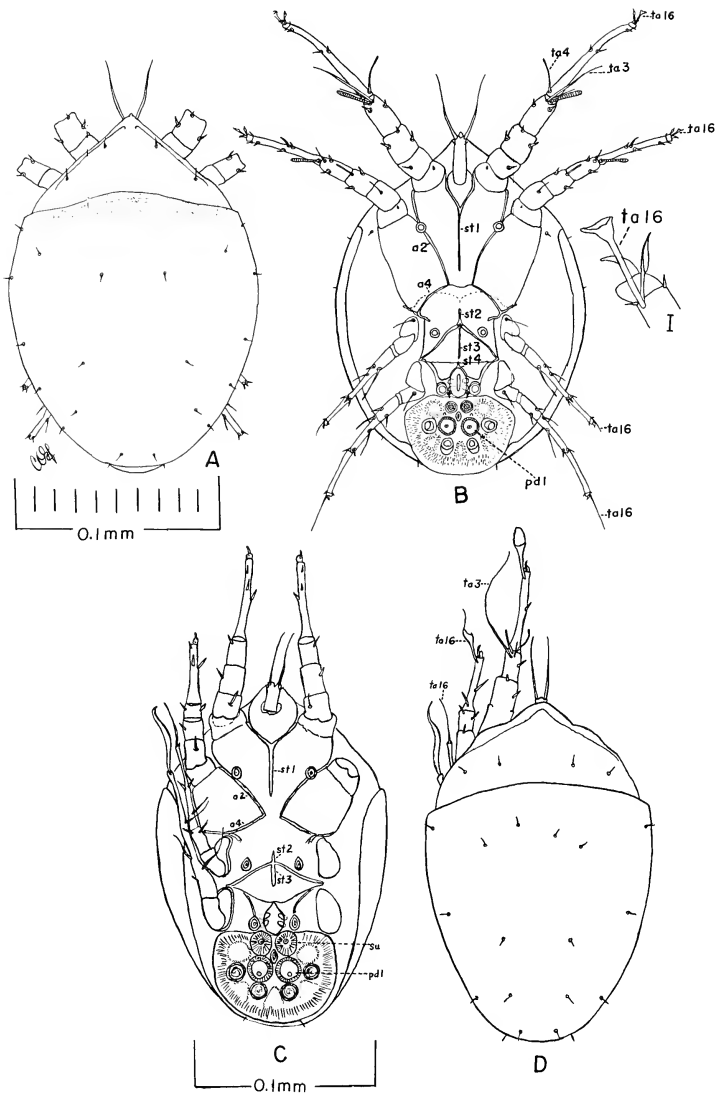


Plate 15 — Upper, *Histiotoma bakeri* sp. nov. deutonymph, A — dorsum, B — venter. Lower, *Histiotoma banjuwangicus* deutonymph. C — venter. D — dorsum. (Original unpublished drawing by A. C. Oudemans).

Natal Museum, Pietermaritzburg, Union of South Africa

National Collection, Ottawa, Canada

USSR Academy of Science, Moscow and Leningrad, USSR

Musee Royal d'Histoire Naturelle de Belgique, Brussels, Belgium

*Histiostoma banjuwangicus* (Oudemans), 1911

(Plate 15)

*Anoetus banjuwangicus* Oudemans, 1911; *Histiostoma banjuwangicus* (Oudemans), 1911 [Buitendijk, 1945].

*Female*. — No information.

*Male*. — No information.

*Deutonymph*. — (Plate 15). Length 0.186 mm.; width 0.124 mm. *Venter*. — Fused pedipalps equal to genu I, seta *pp1* twice length of genu I; sternum *st1* free; *st2* and *st3* short. Apodeme *a2* unites with *a4*. Suctorial plates distinctly large. Functional sucker *su* nearly as large as central plate disc *pd1*. *Dorsum*. — Dorsum non-granular; setae minute, hairlike. Anterior margin of propodosoma undulating. *Legs*. — Seta *ta3*, leg I longer than tarsus I. Seta *ta16*, leg II, lancet-like. Seta *ta16* leg III long, tapering. Leg IV with "saber-shaped end hair."

*Remarks*. — Oudemans does not show a claw on leg III, which, if not an omission, is atypical for anoetids. It is possible that the "end hair" of leg IV represents a modified claw as described for *A. laboratorium*. Seta *vml* and several dorsal setae and leg setae are not shown.

*Collections*. — One specimen from a blattid with hard abdomen, Banjoewangi, Java, 1910, by D. MacGillavry.

*Types*. — Holotype in Oudemans' collection.

*Histiostoma berghi* Jensen, 1895

(Plates 16, 17)

*Female*. — (Plate 16). Length 0.770 mm.; width 0.450 mm. *Venter*. — Chelicera finely serrated, teeth equal. Pedipalpal seta *pp1* equal to tibia I; *pp2* very minute. Ringlike structures *r1* and *r2* small and round; *r1* is more mesially placed than in *H. julorum*. The bursa copulatrix is conical in shape, and is sub-marginal rather than dorsal in position. *Dorsum*. — Smooth; rostrum heavier than for male. *Legs*. — Legs I-II

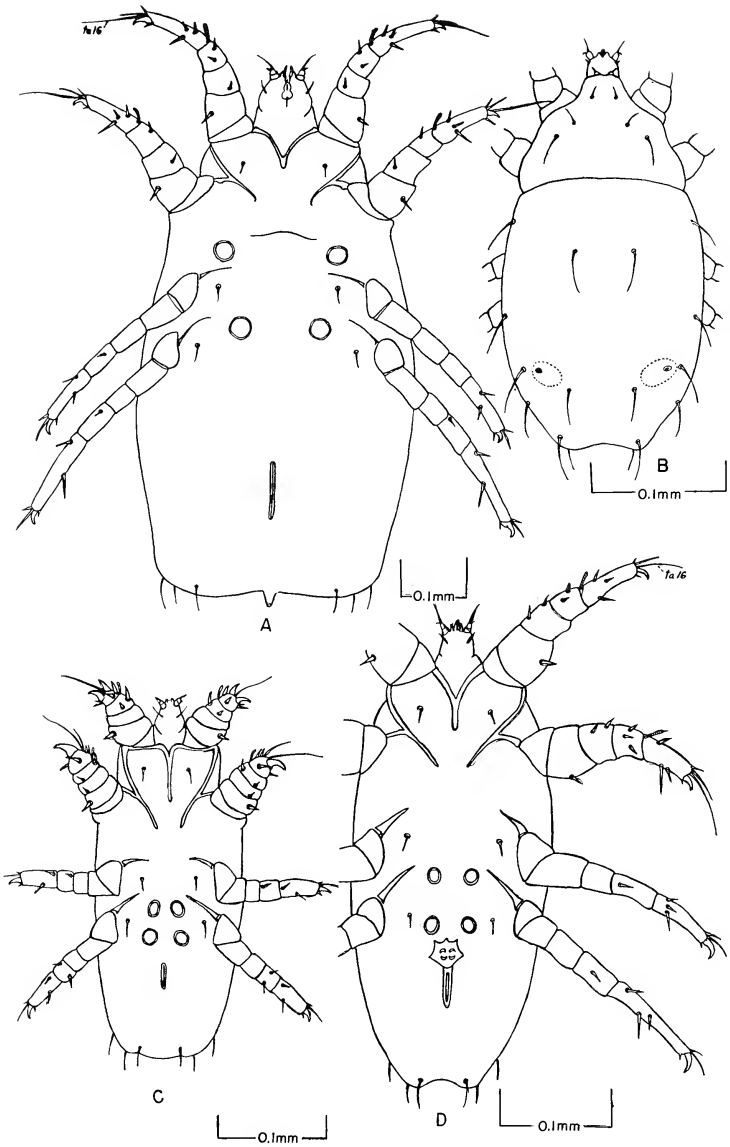


Plate 16 — *Histiostoma berghi*. A — female, venter. B — protonymph, dorsum. C — tritonymph, venter. D — male, venter. (From Jensen)



heavier than legs III-IV. Legs III-IV with terminal setae, twice as long as claw.

*Male*. — (Plate 16). Length 0.390 mm.; width 0.185 mm. *Venter*. — Body elongated. Ringlike structures *r1* and *r2* nearly round, arranged in a square, and lie above the external genitalia. Dorsal setae assumed to be similar to that of protonymph (Plate 16). *Dorsum*. — Smooth. *Legs*. — Seta *ta16* leg I more than half as long as in female. Femur leg II unusually heavy. Relative leg size, arrangement, and type of setae similar to female. Terminal seta legs III-IV longer than claw.

*Deutonymph*. — (Plate 17). Length 0.250 mm.; width 0.163 mm. *Venter*. — Fused pedipalps equal to tibia I. Seta *pp1* twice length of tibia I. Sternum *st1*, and apodeme *a2* long and free. Apodemata *a4* continuous in midline. Sternum *st2* not continuous with *a4*. Suctorial plate distinctly large. *Dorsum*. — On the basis of incomplete description, dorsum assumed to be smooth; setae small and equal in length. *Legs*. — Seta *ta3* leg I one-half length of tarsus I; seta *ta4* nearly as long as *ta1*. Seta *ta16* tarsus II long, tapering, and equal in length to *ta16* legs III-IV.

*Tritonymph*. — (Plate 16). Length 0.316 mm.; width 0.132 mm. Ringlike structures *r1* and *r2* similar in arrangement to the tritonymph of *H. julorum*. Legs I-II shortened and enlarged in contrast to legs III-IV, and distinctly shorter than is typical for other anoetid species. Tarsal setae of legs I-II usually spine-like.

*Remarks*. — The dorsal setal pattern of all species of protonymphs examined closely indicates that this pattern is the same for the adult male. Hence, it is assumed that such is the case for this species and that some few setae were overlooked. Jensen believed that the stout legs I-II of the tritonymph were modified for the purpose of boring into a cocoon and records one instance in which this was actually observed. (See *H. murchiei* under remarks). Apparently Jensen failed to observe a considerable number of setae on the body and legs. Comparison of *H. berghi* with *H. murchiei* is invited since these are the only two species which are known to be parasitic or semi-parasitic, both feeding on the eggs or larva in the cocoons of annelids. Females of both species are usually large, have distinctly round anterior ringlike discs *r1*, and a nearly marginal bursa copulatrix. Both species are remarkable for the extremely small gnathosoma and delicate gnathosomal structures in the adult. The dissimilarity of the deutonymphs of *H. murchiei* and *H. berghi* is quite striking, and the possibility exists that the deutonymph of *H. berghi* is not correctly associated with the adults of this species.

*Collections*. — From the beach of a pond near Copenhagen, all stages in cocoons of the horse leech, *Aulastoma gulo*.

*Types*. — No record.

*Histiostoma brevimanus* (Oudemans), 1914

(Plate 18)

*Lipstorpia brevimanus* Oudemans, 1914; *Anoetus brevimanus* Oudemans, 1917; *Histiostoma brevimanus* (Oudemans), 1917 [Buitendijk, 1945].

*Female.* — No information.

*Male.* — No information.

*Deutonymph.* — (Plate 18). Length 0.155 mm.; width 0.111 mm. Color light yellow-brown. *Venter.* — Fused pedipalps equal to genu I. Seta *ppl* twice length of genu I. Sternum *st1* and apodeme *a2* ending free. Apodemata *a4* continuous in midline and joined to *st2*. Functional suckers *su* and all proximal discs approximately equal in diameter. *Dorsum.* — Ellipsoid. Finely striped longitudinally. All setae extremely minute. *Legs.* — Tarsus I relatively short in comparison with other species. All

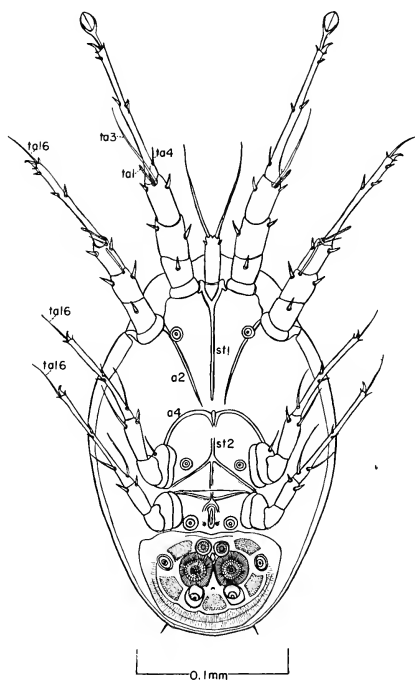


Plate 17 — *Histiostoma berghi* deutonymph, venter. (From Jensen)

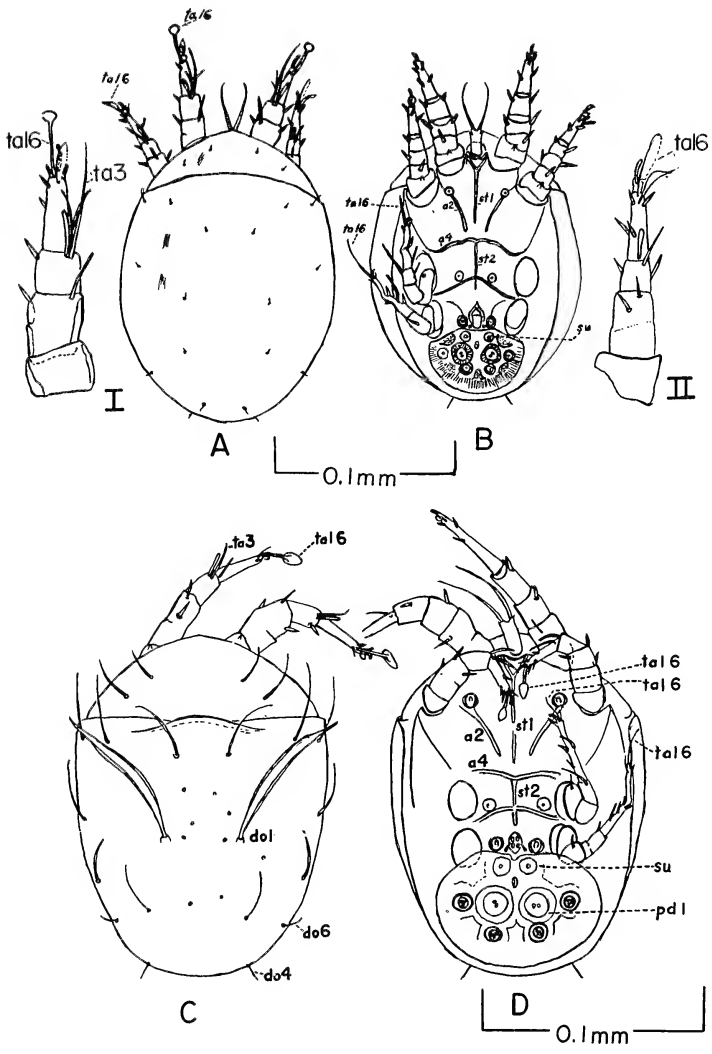


Plate 18 — Upper, *Histiostoma brevimanus* deutonymph. A — dorsum. B — venter. Left — leg I. Right — leg II. (Original unpublished drawing by A. C. Oudemans) Lower, *Histiostoma ensifer* deutonymph. C — dorsum. D — venter (Original unpublished drawing by A. C. Oudemans)

legs shorter than typical. Seta *ta16* leg I spoon-shaped; *ta16* leg II lancet-shaped; *ta16* leg III tapering, shorter than *ta16* leg IV. Seta *ta3* longer than tarsus I.

*Remarks.* — Description based on a single imperfect specimen. Certain body and leg setae apparently inadvertently omitted.

*Collections.* — One specimen in a hot bed, Sittard, Netherlands, May 1912; collected by F. Heselhaus.

*Types.* — In Oudemans' collection.

*Histiostoma campanula* (Oudemans), 1914

(Plate 19)

*Anoetus campanula* Oudemans, 1914; *Histiostoma campanula* (Oudemans), 1914 [Buitendijk, 1945].

*Female.* — No information.

*Male.* — No information.

*Deutonymph.* — (Plate 19). Length 0.211 mm.; width 0.140 mm. *Venter.* — Fused pedipalps equal to genu I. Seta *pp1* equal in length to tarsus II. Sternum *st1* long and free. Apodemata *a2* nearly joining with *a4*, which latter are faintly membranous in midline. Sternum *st2* Y-shaped anteriorly. Coxal discs *di1* and *di2* definitely smaller than *di3*. *Dorsum.* — Smooth; pear-shaped; pedipalpal base extending beyond the anterior margin of propodosoma. Setae minute and hairlike. *Legs.* — Seta *ta16* leg I cup-shaped; *ta16* leg II lancet-shaped; *ta16* leg III twice as long as claw. Tarsus I seta *ta3* only slightly longer than *ta1*; femoral setae *f* legs I-II and trochanter seta *t* leg III distinctly longer than corresponding setae of *H. julorum*.

*Remarks.* — Only deutonymph of *H. fimetarium* is as distinctly pear-shaped as this species. The minute knob on the end of seta *ta16* leg III, if correctly described, is unique among the anoetids. All body and leg setae apparently not observed by Oudemans.

*Collections.* — Banjoewangi, Java, 1911; by D. MacGillavry.

*Types.* — Holotype in Oudemans' collection.

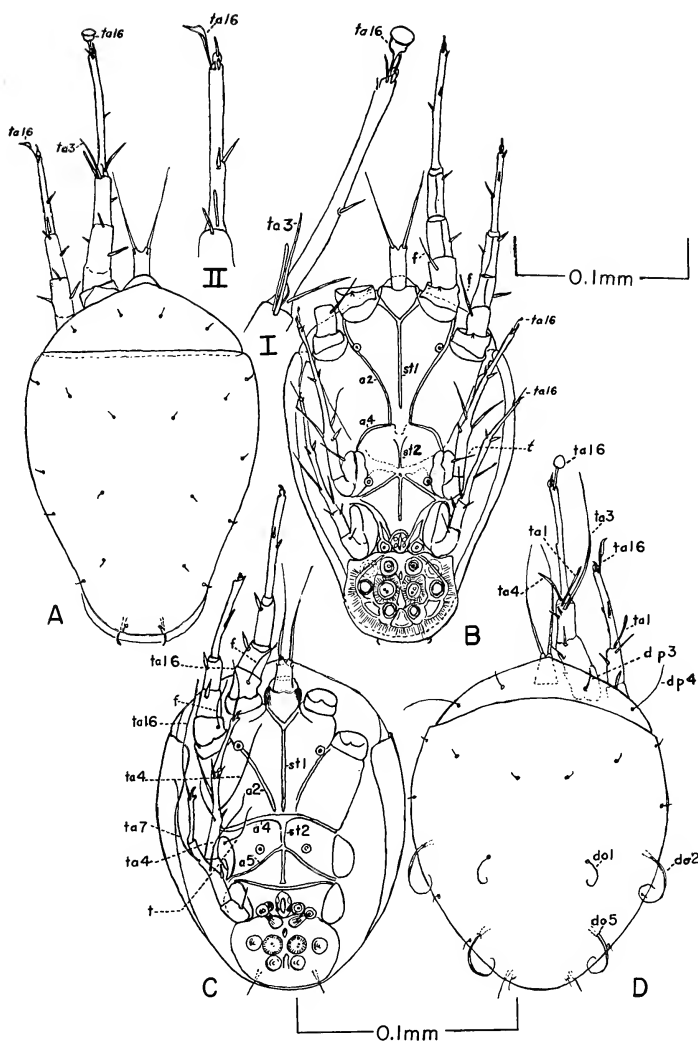


Plate 19 — Upper, *Histiostoma campanula* deutonymph. A — dorsum. B — venter. (Original unpublished drawing by A. C. Oudemans) Lower, *Histiostoma cirratus* deutonymph. C — venter. D — dorsum. (Original unpublished drawing by A. C. Oudemans)

*Histiostoma cirratus* (Oudemans), 1911

(Plate 19)

*Anoetus cirratus* Oudemans, 1911; *Histiostoma cirratus* (Oudemans, 1911) [Buitendijk, 1945].

*Female*. — No information.

*Male*. — No information.

*Deutonymph*. — (Plate 19). Length 0.150 mm.; width 0.115 mm. *Venter*. — Fused pedipalps slightly tapering distally; equal in length to genu I. Seta *pp1* equal in length to tarsus I. Sternum *st1*, and apodeme *a2* touching or nearly touching *a4*. Apodemata *a4* strong, continuous in midline. Sternum *st2* united with *a4* and *a5*. *Dorsum*. — Smooth; setae variable in length; seta *dp4* over twice as long as *dp3*; seta *do2* and *do5* longer than *dp4* and curly; seta *do1* shorter than *dp4* and curly; other setae minute and hairlike. *Legs*. — Tarsus I seta *tal6* spoon-shaped; seta *tal6* leg II lancet-shaped; seta *tal6* leg III tapering, longer than *dp4*; *tal6* leg IV hairlike, longer than *pp1*. Seta *f* legs I-II, and seta *t* leg III equal in length to *dp4*. Seta *ta3* leg I longer than tarsus I; *ta4* leg I equal in length to *tal1*. Seta *ta4* leg III, *ta4* and *ta7* leg IV extremely long and hairlike.

*Remarks*. — This species is unusual in that it has a large number of extremely long leg setae, and that in general there is extreme variability in size and type of leg and body setae. The full complement of leg setae is not shown.

*Collections*. — 2 specimens from a blattid with hard abdomen, Banjoewangi, Java; collected by D. MacGillavry in 1910.

*Types*. — Holotype in Oudemans' collection.

*Histiostoma crassipes* (Oudemans), 1912

(Plate 20)

*Anoetus crassipes* Oudemans, 1912; *Lipstorpia crassipes* Oudemans, 1914; *Histiostoma crassipes* (Oudemans), 1914 [Buitendijk, 1945].

*Female*. — No information.

*Male*. — No information.

*Deutonymph*. — (Plate 20). Length 0.190 mm.; width 0.120 mm.; color light brown. *Venter*. — Fused pedipalps slightly separated, wide at

base and tapering distally. Seta *pp1* equal in length to tarsus II. Sternum *st1* and apodemata *a2* free but converging near midline. Apodemata *a4* and *st2* faintly united in midline. *Dorsum*. — Smooth. Hysterosomal setae minute, hairlike, and equal in length. Seta *dp3* twice as long as *dp4*; *dp4* equal in length to tibia I. *Legs*. — Seta *ta16* leg I-II spoon-shaped; legs III-IV without long tapering seta *ta16*. Femur I-II short; seta *f* legs I-II, and *t* leg III three times as long as corresponding setae in *H. julorum*. Genu I and tibia I enlarged; genu and tibia I-II setae stout, spine-like; tarsus I seta *ta3* equal in length to tarsus II. Tarsus IV seta *ta4* equal in length to *pp1*.

*Remarks*. — The unusual structure of legs I-II was interpreted by Oudemans and Vitzthum (1923) as a fusion of genua and femurs. The presence of a typical seta *f* indicates that the true femur is foreshortened, and that the genu is correspondingly enlarged and pseudosegmented. A full typical complement of leg setae is not shown. Oudemans (1914a) placed this species in the genus *Lipstorpia*, but in 1917 returned it to *Anoetus*.

*Collections*. — Borne on *Platypus dispar* Schauff II (Platypodidae) in a forest at 1000 meters altitude on Mikulumusi Mountain, and 2 specimens on *Hololepta africana* Lew. (Histeridae), Amani, Dutch East Africa, July 1911; discovered by Vitzthum on *Ips stebbingi* Strohmeier in collection by H. Wichmann from Kutu, Himalaya.

*Types*. — Holotype in Natural History Museum, Hamburg, Germany.

*Histiostoma crenulatus* (Oudemans), 1909

(Plate 20)

*Anoetus crenulatus* Oudemans, 1909; *Histiostoma crenulatus* (Oudemans), 1909 [Buitendijk, 1945].

*Female*. — No information.

*Male*. — No information.

*Deutonymph*. — (Plate 20). Length 0.195 mm.; width 0.157 mm. *Venter*. — Fused pedipalps equal in length to genu I. Seta *pp1* equal in length to tarsus II. Sterna *st1*, *st2*, and *st3* united. Apodemata *a2* end anteriorly at disc *dil*, and join *a4* posteriorly. Apodemata *a4* distinctly continuous in midline. Seta *vm1* described but not shown in drawing. *Dorsum*. — Smooth, except anterior margin of hysterosoma distinctly crenulated. Setae minute, hairlike, and equal. Propodosoma shortened. *Legs*. — Seta *ta16* legs I-II distinctly large, lancet-shaped; *ta16* leg III unstalked, oval, smaller than *ta16* leg II; distal tarsal seta leg IV tapering, twice length of *pp1*. Other setae leg IV generally short, spine-like.

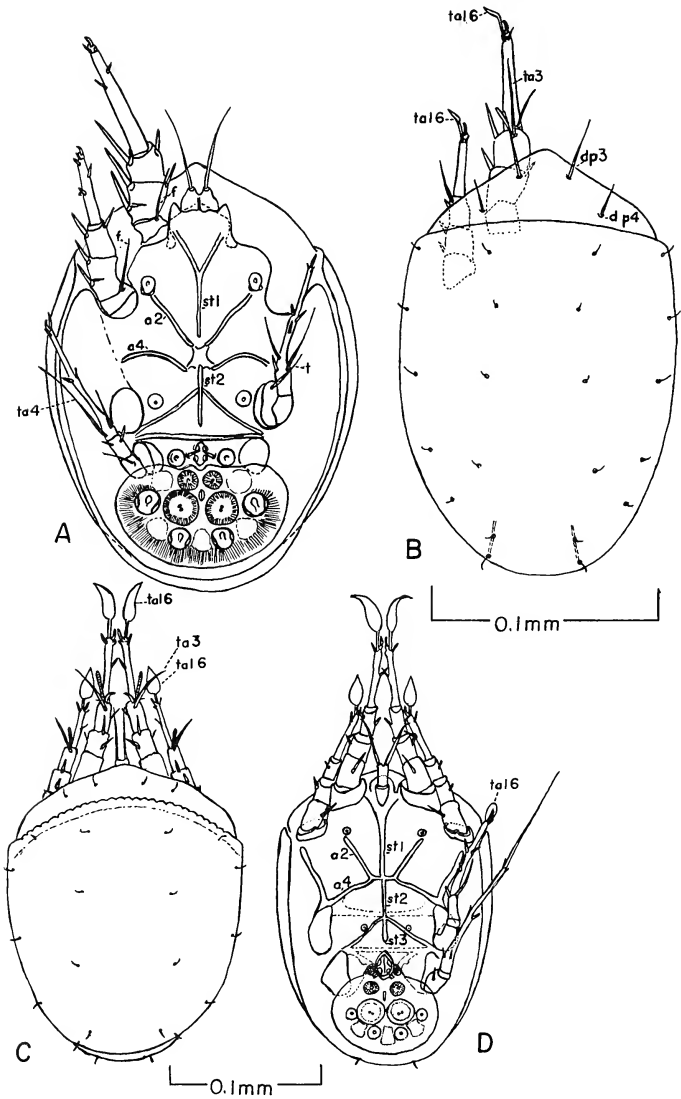


Plate 20 — Upper, *Histiotostoma crassipes* deutonymph. A — venter. B — dorsum. (Original unpublished drawing by A. C. Oudemans) Lower, *Histiotostoma crenulatus* deutonymph. C — dorsum. D — venter. (Original unpublished drawing by A. C. Oudemans)



Seta *ta3* leg I equal in length to *pp1*.

*Remarks.* — Oudemans (1924c) erroneously identified *Hypopus setipes* Koch, 1847 as *H. crenulatus*. He corrected this misidentification in 1937. Crenulation of hysterosoma and oval seta *ta16* leg III are very distinctive. Full typical complement of leg setae not shown.

*Collection.* — On *Necrophorus vespillo* from Arnhem, Netherlands, Sept. 1909.

*Types.* — Holotype in Oudemans' collection.

*Histiostoma cyrtandrae* (Vitzthum), 1931, new combination  
(Plate 21)

*Anoetus cyrtandrae* Vitzthum, 1931.

*Female.* — (Plate 21). Length 0.420 mm.; width 0.230 mm. *Venter.* — Chelicera finely serrated, bearing approximately 30 fine teeth of equal size; cheliceral flagellum shorter than toothed area. Seta *pp1* medium in length, over twice as long as *pp2*. Anterior ringlike structures nearly shoe-shaped; posterior ringlike structures distinctly elongated. Setae similar in size and arrangement to *H. julorum*, except *vm3* is mesiad of *r2*, and *vo3* is much longer. *Dorsum.* — Dorsum finely granular or with tiny points. Rostrum heavily granular and mildly sculptured. Except *dp1*, *dp2*, and *dp3* dorsal setae over twice as long as *pp1*, and slightly variable in length and thickness. The bursa copulatrix is on a line with setae *do1*, a position more anterior than is typical, and bearing an anterior boss. *Legs.* — The leg setae are generally heavier than *H. julorum*. Long tapering terminal tarsal setae *ta9* are present on legs III-IV. All claws are heavier than in *H. julorum*.

*Male.* — This species is thelytokous.

*Deutonymph.* — (Plate 21). Length 0.198 mm.; width 0.138 mm. *Venter.* — Fused pedipalps slightly longer than tibia I; *pp1* nearly as long as tarsus II. Sternum *st1* meets the faintly connected *a4*; apodeme *a2* faintly connected to *a4*. Sternum *st3* expanded posteriorly and faintly joined to *st4*. *Dorsum.* — Propodosoma pointed anteriorly with faint transverse sculpturing; anterior margin of hysterosoma transversely striated. Lateral margins of the hysterosoma sometimes appear to be faintly sculptured. Dorsal setae only slightly variable in length, hairlike, and generally equal in length to genu I. *Legs.* — Seta *ta3* leg I over one-half as long as tarsus I; setae *f* legs I-II, and IV, and seta *t* leg III shorter than in *H. julorum*. Seta *ta4* leg III spine-like. Seta *ta16* leg I elongated, spoon-shaped; *ta16* leg II lancet-shaped, *ta16* leg III spatulate, *ta16* leg

IV long, tapering with rounded end.

*Remarks.* — The combination of adult characteristics most useful in identifying this species is: the heavy but finely serrated chelicera, the medium length of the pedipalpal seta *pp1*, the elongated posterior ring-like structures, seta *vm3* mesiad of *r2*; strong, elongated, dorsal setae and claws. For the deutonymph, length of pedipalp and seta *pp1*, arrangement of apodemata, transverse striations on anterior dorsal hysterosoma, medium hairlike dorsal setae, and shape of *tal6* all legs, especially leg III which is uniquely spatulate. Vitzthum did not describe the deutonymph. It is worthy of note that this is one of the two *Histiostoma* species known to thrive completely submerged. Both were collected by R. F. Nigrelli in the same goldfish tank on different dates. This species has been cultured on moist housefly media in this laboratory for over two years, indicating that it tolerates submergence but does not require it. Not attempt was made to culture the other species, *H. nigrellii*, on housefly media, and it was subsequently lost (see below). It is also of interest that both species have been associated with the death of fish. R. F. Nigrelli in a personal communication states that a preliminary investigation indicates that some unidentified toxic substance is given off by these mites which is lethal to guppies and goldfish. If this observation is confirmed it will be the first known instance of an anoetid giving off a toxic substance. Since other lethal agents were not entirely ruled out by Nigrelli's observations, it appears quite possible that the mites were simply scavengers associated with fish whose death was due to an unknown cause.

*Collections.* — One adult female and one tritonymph in the axil fluid of an Araceae, *Colocasia indica*, near the sea of Ngebel, in middle Java, Dec. 1928. One adult female and great numbers of protonymphs and tritonymphs in the water filled bases of the flower, *Cyrtandra glabra*, in a forest near Ranau, southern Sumatra, March, 1929. (Vitzthum 1931). In a goldfish tank at the Aquarium, New York Zoological Society, October, 1954. Collected by Ross F. Nigrelli.

*Types.* — Holotype probably in Vitzthum's collection. Plesiotypes (supplied by present authors) as follows:

U. S. National Museum, Washington, D. C.

British Museum of Natural History, London, England

Rijksmuseum van Natuurlijke Historie, Leiden, Netherlands

Museum National d'Histoire Naturelle, Paris, France

The South Australian Museum, Adelaide, South Australia

Natal Museum, Pietermaritzburg, Union of South Africa

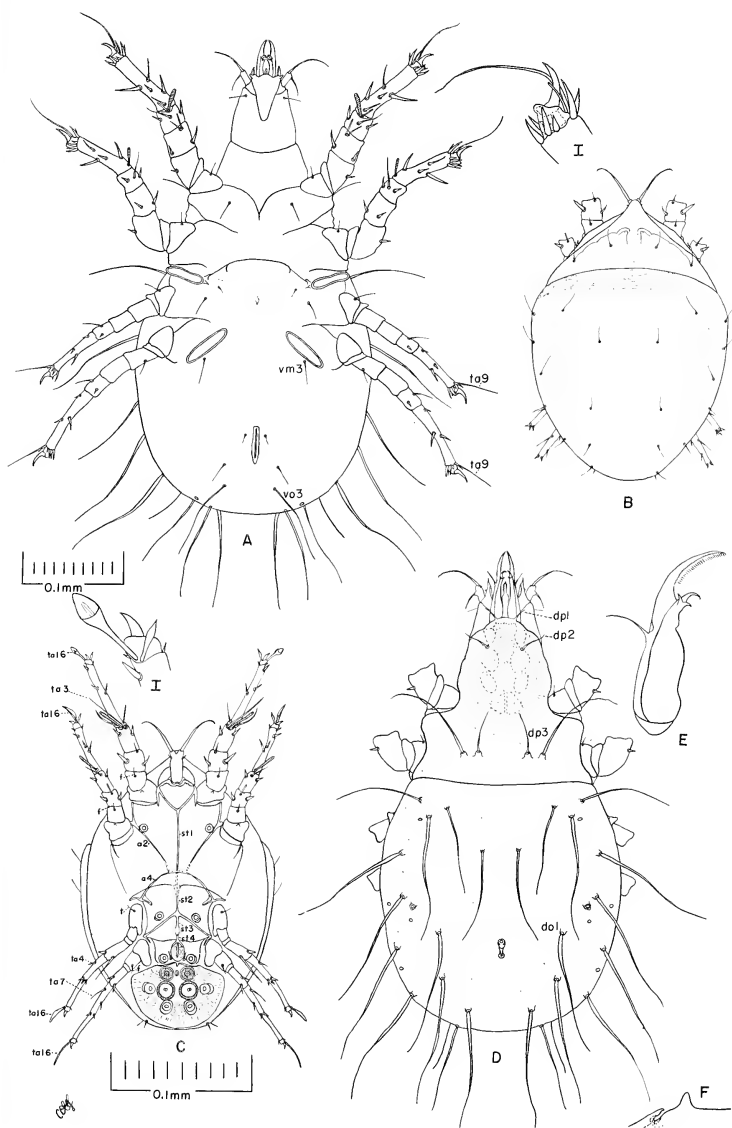


Plate 21 — *Histiostoma cyrtandrae*. A — female, venter. B — deutonymph, dorsum. C — deutonymph, venter. D — female, dorsum. E — chelicera. F — bursa copulatrix.

National Collection, Ottawa, Canada

USSR Academy of Science, Moscow and Leningrad, USSR

Musee Royal d'Histoire Naturelle de Belgique, Brussels, Belgium

*Histiostoma ensifer* (Oudemans), 1912

(Plate 18)

*Anoetus ensifer* Oudemans, 1912; *Histiostoma ensifer* (Oudemans), 1912 [Buitendijk, 1945].

*Female*. — No information.

*Male*. — No information.

*Deutonymph*. — (Plate 18). Length 0.135 mm.; width 0.096 mm. *Venter*. — Fused pedipalps equal in length to tibia I. Seta *pp1* nearly equal in length to tarsus I. Sternum *st1* and apodeme *a2* end free. Apodemata *a4* united with *st2*, and continuous in midline. Suctorial plate distinctly large. *Dorsum*. — Hysterosoma faintly pitted. One pair of strong saber-shaped setae *do1*. Remainder of setae variable in length, hairlike, and except for *do4* and *do6* shorter than tibia I. *Legs*. — Seta *ta16* legs I-II spoon-shaped; *ta16* leg III hairlike, twice as long as claw. Seta *ta16* leg IV hairlike and twice as long as *ta16* leg III. Seta *ta3* leg I half as long as tarsus I.

*Remarks*. — Anterior fold of hysterosoma may be artifact according to Oudemans. Seta *ta16* leg II indistinctly spoon-shaped. Oudemans states that discs *di1* and *di3* are heavier and more distinct than *su* and *pd1*. A few of the typical complement of leg setae and two body setae are not shown.

*Collections*. — One specimen on Passilide in Amani, Dutch East Africa, August 1911.

*Types*. — Holotype in Natural History Museum in Hamburg, Germany.

*Histiostoma feroniarum* (Dufour), 1839

(Plates 22, 23)

*Hypopus feroniarum* Dufour, 1839; *Tyroglyphus feroniarum* (Dufour), 1839 [Moniez, 1893]; *Anoetus feroniarum* (Dufour), 1839 [Oudemans, 1897]; *Histiostoma feroniarum* (Dufour), 1893 [Canestrini, 1899]; *Hypopus dugesi* Claparede, 1868; *Anoetus dugesi* (Claparede), 1868 [Oude-

mans, 1909]; *Tyroglyphus rostro-serratus* Megnin, 1873; *Histiostoma rostro-serratus* (Megnin), 1873 [Berlese, 1881]; *Histiostoma rostro-serratum* (Megnin), 1873 [Jary and Stapley, 1936]; *Rhizoglyphus rostro-serratus* Murray, 1877; *Acarus mammillaris* Canestrini and Fanzago, 1876; *Phyllostoma pectineum* Kramer, 1876; *Histiostoma pectineum* Kramer, 1876; *Serrator amphibius* Megnin, 1880; *Histiostoma americanum* Banks, 1906; *Histiostoma gracilipes* Banks, 1906.

*Female*. — (Plate 22). Length 0.250 mm.; width 0.300 mm. *Venter*. — Chelicera serrated with seven large teeth proximally, approximately six minute teeth distally, and ending in a distinct bristle. Chelicercal flagellum longer than in *H. julorum*. Distinct membranous structure associated with the pedipalp. Seta *pp1* slightly longer and heavier than *pp2*. Anterior ringlike structure *r1* typically elongate; *r2* typically round or oval. Setae short, hairlike and nearly equal except for *vm1*. Seta *do7* ventral instead of dorsal or marginal. *Dorsum*. — Rostrum sculptured; dorsum finely granular. Setae similar in size and arrangement to *H. julorum* except for *dp1*. Bursa copulatrix raised, heavily granular, and opening anteriorly. *Legs*. — Shape, size, and setae arrangement similar to *H. julorum* except seta *ti2* legs I-II over three times longer than other tibial setae; trochanter setae legs I-III, and femoral seta leg IV shorter.

*Male*. — (Plate 22). Length 0.362 mm.; width 0.230 mm. Body more shield-shaped, less elongated than *H. julorum*. *Venter*. — Gnathosoma as in female. Ringlike structures nearly round and arranged in a square above the external genitalia. Setae nearly equal; generally shorter, but similar in arrangement to *H. julorum* except *vm1* lateral to *r1*; *vo1*, *vo2*, and *vo3* are borne on a distinct genital plate which surrounds the anus and external genitalia. Seta *do4* marginal in position; pit-like structure *dpi4* is ventral. *Dorsum*. — Rostrum faintly sculptured; dorsum finely granular. Dorsal setae similar in size and arrangement to *H. julorum* except: *dp1* shorter, *dp2* longer, and *do4* ventral. *Legs*. — Legs more robust; setae generally heavier, especially tarsus II setae, than in *H. julorum*. Seta *ta8* leg II about as stout as claw, a feature unique for this species. Setae *ti2* legs I-II, trochanter setae *t* legs I-III, and femoral seta *f* leg IV as in female.

*Deutonymph*. — (Plate 23). Length 0.178 mm.; width 0.130 mm. *Venter*. — Fused pedipalps equal in length to genu II; seta *pp1* equal to tarsus II. Sternum *st1* free; apodemata *a2* barely touching *a4*; apodemata *a4* faintly continuous in midline; *st2* free; coxal discs *di1* and *di2* smaller than *di3*. *Dorsum*. — Dorsum smooth except for the single line of transverse sculpturing on propodosoma and transverse striations on anterior margin of the hysterosoma. Setae minute, hairlike, and equal. *Legs*. — Seta *ta16* leg I spoon-shaped; *ta16* leg II lancet-shaped; *ta16* leg III tapering, three times as long as claw; *ta16* leg IV tapering, four times as long as

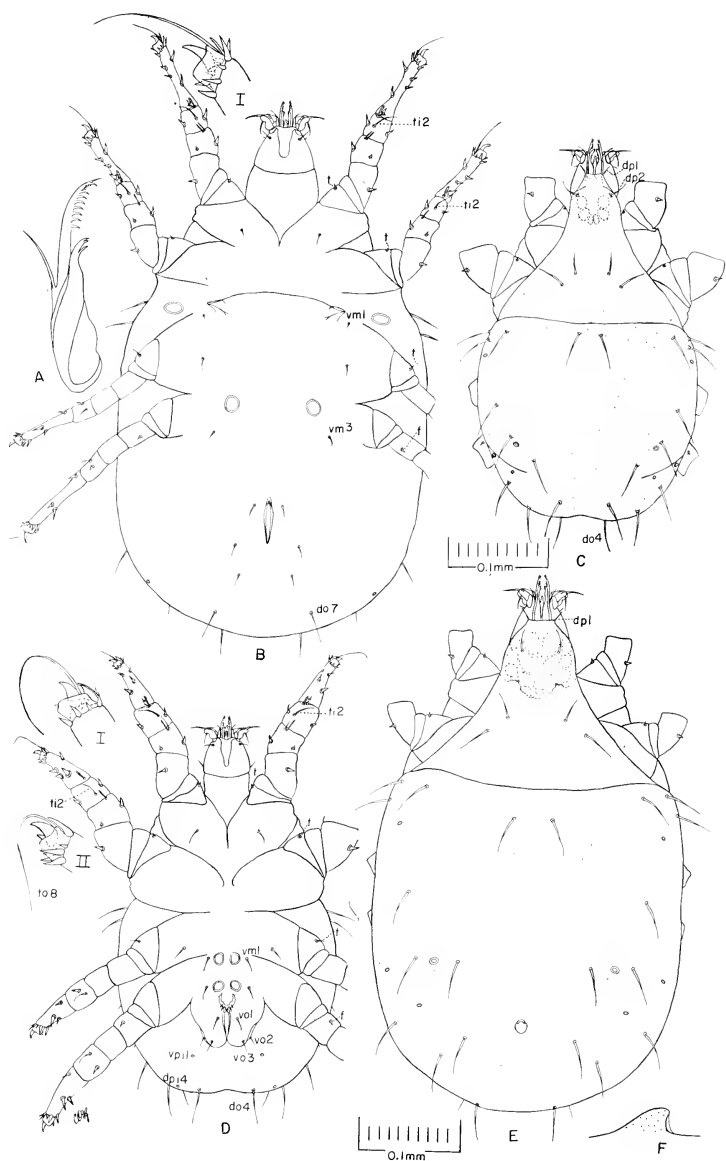


Plate 22 — *Histiostoma feroniarum*. A — chelicera. B — female, venter. C — male, dorsum. D — male, venter. E — female, dorsum. F — bursa copulatrix.

claw. Seta *ta4* leg I with rounded end. Seta *ta3* leg I equal to genu II plus tibia II; *ta4* leg III, *ta4* and *ta7* shorter than in *H. julorum*.

*Remarks.* — This species is most remarkable in having what we provisionally regard as two distinct “varieties,” one thelytokous and the other arrhenotokous. Stocks of both have been maintained in our laboratory for over five years. Morphologically the females and deutonymphs of both “varieties” are essentially indistinguishable. It appears that the thelytokous female is usually somewhat smaller than the arrhenotokous female. Observations on the chromosome numbers and cross-breeding of these two “varieties” have not been completed. The deutonymph is difficult to distinguish from *H. bakeri* and *H. humiditatis* Oudemans (1924c) synonymized this species with *H. insularis* (Oudemans), 1914. On the basis of published figures and description we have taken the position that this is an incorrect synonymy. The combination of adult characteristics most useful in identifying this species is: short but laterally directed pedipalpal setae *pp1*; membranous structures associated with pedipalps; shape of ringlike structures; and position of seta *vm3*. Different collections have yielded what appears to be slight variations in distinctness of protuberances, and ventral discs size. These variations are not considered to be sufficient evidence for the establishment of true varieties.

*Collections.* — This species has a wide distribution and has been found in many kinds of decaying vegetation. Collected by Dufour in exudate of Asiatic spiny tree (*Feroniae*) 1893; by Megnin on mushrooms in France, 1873; by Canestrini and Fanzago on fungus from Maser in Trevigiano, 1876; by Murray on potatoes in barn at Vincennes, France, 1877; by Moniez in fungus beds from Lille, France, 1893; by Megnin on mushrooms, decomposed fruit, and sauerkraut, 1880; by Kramer and Canestrini from decayed mushrooms and under tree bark, Europe, 1899; by Banks from decayed leaves, Washington, D. C., 1899; by Zacher from potato tubers in Austria, 1920; by Womersley on tiger lily, Lindfield, New South Wales, May, 1932; by Womersley from dahlia tuber, Bathurst, New South Wales, November, 1932; by Womersley in moss, Mount Barker, South Australia, June, 1934; by Jary and Stapley many collections, especially in stable manure (with *H. pyri-forme*), 1936; by Womersley on milliped, Hallet, South Australia, 1938; by Womersley on rotting bulbs, Auckland, New Zealand, January, 1940. *Arrhenotokous* “variety.” — Collected by R. D. Hughes in woods near Ellerson, Va., July 1950 and in compost heaps near Ellerson, Va., October and January, 1950. *Thelytokous* “variety.” — Collected by Mr. John Steves in woods near Waynesboro, Va., July, 1950; by Alexander Sokaloff in oak slime flux, Mather, Calif., July, 1950; by R. D. Hughes in wooded area, Norris Dam, Tenn., July 1951; by F. C. McDowell in woods, Vernon Hill, Va., June, 1952; by R. D. Hughes in walnut hulls near Ellerson, Va., December, 1952; by A. H. O'Bier near Warsaw, Va., June,

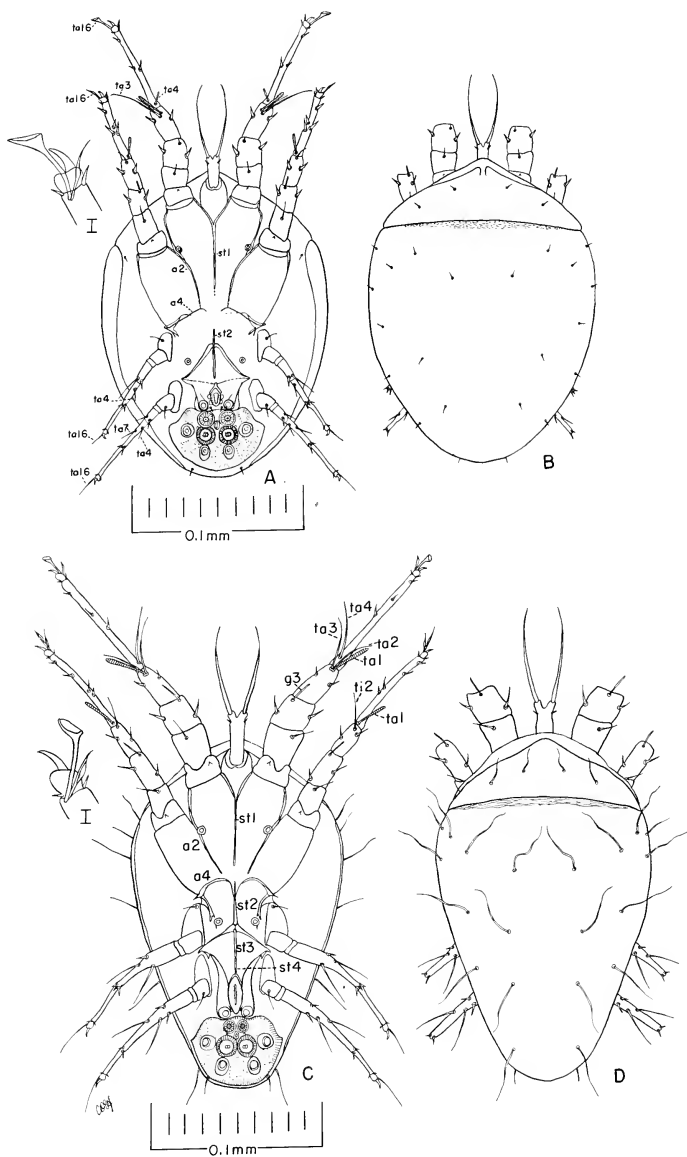


Plate 23 — Upper, *Histiostoma feroniarum* deutonymph. A — venter. B — dorsum. Lower, *Histiostoma fimetarium* deutonymph. C — venter. D — dorsum.



1954; by F. A. Robertson in moist woods near Ellerson, Va., September, 1955; by W. C. Crites south of James River near Richmond, Va., June, 1955.

*Types*. — Holotype no record. Plesiotypes (supplied by present authors) located as follows:

U. S. National Museum, Washington, D. C.

British Museum of Natural History, London, England

Rijksmuseum van Natuurlijke, Leiden, Netherlands

Museum National d'Histoire Naturelle, Paris, France

The South Australian Museum, Adelaide, South Australia

Natal Museum, Pietermaritzburg, Union of South Africa

National Collection, Ottawa, Canada

USSR Academy of Science, Moscow and Leningrad, USSR

Musee Royal d'Histoire Naturelle de Belgique, Brussels, Belgium

*Histiostoma fimetarium* Canestrini and Berlese, 1881

(Plates 23, 24)

*Hypopus fimetarius* Canestrini and Berlese, 1881 [Berlese, 1883]

*Female*. — (Plate 24). Length 0.380 mm.; width 0.225 mm. *Venter*. — Chelicera non-serrated, pointed distally; median chelicercal process not frayed or forked; chelicercal flagellum over one-half length of tarsus I; seta *pp1* nearly twice as long as tarsus I, finely tapering; *pp2* one-half as long as tarsus I. Ringlike structure *r2* elongated. Setae similar in size and arrangement to *H. julorum*, except for *vm1* which is one-half as long; *vm3* which lies laterad of *r2*; *vo1* twice as long; *vo3* one-half as long; and *do7* marginal in position. *Dorsum*. — Dorsum sometimes with minute projections giving a fuzzy appearance; rostrum heavily granular. Setae *dp1*, *dp2*, and *dp3* similar to *H. julorum*, other setae one-third longer. Bursa copulatrix raised, heavily granular, and opening anteriorly. *Legs*. — The size and arrangement of leg setae is similar to *H. julorum* except: trochanter setae legs I-III, femoral seta leg IV, and setae *ti2* legs I-II slightly longer; terminal tarsal setae slightly stouter and longer. Seta *ta2* leg I nearly equal to *ta1*.

*Male*. — (Plate 24). Length 0.290 mm.; width 0.140 mm. *Venter*. — Gnathosoma as in female. Ringlike structures *r2* on level with external

genitalia, round or oval, smaller and more widely separated than in *H. julorum*. Setae similar in arrangement, but generally shorter than in *H. julorum* except *vm3* is laterad and anteriad of *r2*. *Dorsum*. — Entire dorsum finely granular and sometimes with minute projections. Hysterosomal setae slightly longer than in *H. julorum*. *Legs*. — Leg setae similar in arrangement to female.

*Deutonymph*. — (Plate 23). Length 0.200 mm.; width 0.125 mm. Soma distinctly pear-shaped. *Venter*. — Fused pedipalps longer than tibia I; *pp1* equal to tarsus II; *st1* and *a2* free; *a4* faintly joined to *st2*; *st3* and *st4* nearly touching; *di3* posterior to trochanter IV. *Dorsum*. — Smooth, except for transverse striations on anterior margin of hysterosoma; faint membranous structure anterior to propodosoma. Propodosomal setae hairlike and equal to genu I; hysterosomal setae flexible and longer than tibia I. *Legs*. — In comparison with *H. julorum* trochanters III-IV closer to midline; leg I seta *g3* longer, *ta1* and *ta2* one-half length of tarsus II, *ta4* equal to *ta3*; leg II *ti2* longer, *ta1* larger.

*Remarks*. — The female is readily separated from most other species on the basis of the unusually long dorsal setae, non-serrated chelicera, long *pp1*, arrangement of small, ringlike structures in the form of a trapezoid, and position of *vm3* anterio-laterad of *r2*. The deutonymph is distinctly pear-shaped with long, hairlike dorsal setae, and with distinctive, transparent membrane extending anteriorly beyond the propodosoma. Canestrini and Berlese show two anterior suckers on the venter of the male. This observation must have been in error. Repeated but unsuccessful attempts to obtain offspring from isolated virgin females have been made. It would appear that this species is not arrhenotokous. If these observations are correct it is the only species of the Anoetidae so far examined which is not parthenogenetic. This problem is receiving further study and is discussed below.

*Collections*. — Collected by Canestrini and Berlese from dung, Padova, Italy, February, 1881; by R. D. Hughes from Chickahominy Swamp, August and September, 1953.

*Types*. — Holotypes no record. Plesiotypes (supplied by present authors) in U. S. National Museum, Washington, D. C. Plesiotypes in authors' collection.

*Histiostoma gladiger* (Vitzthum), 1926, new combination

(Plate 25)

*Anoetus gladiger* Vitzthum, 1926

*Female*. — No information.

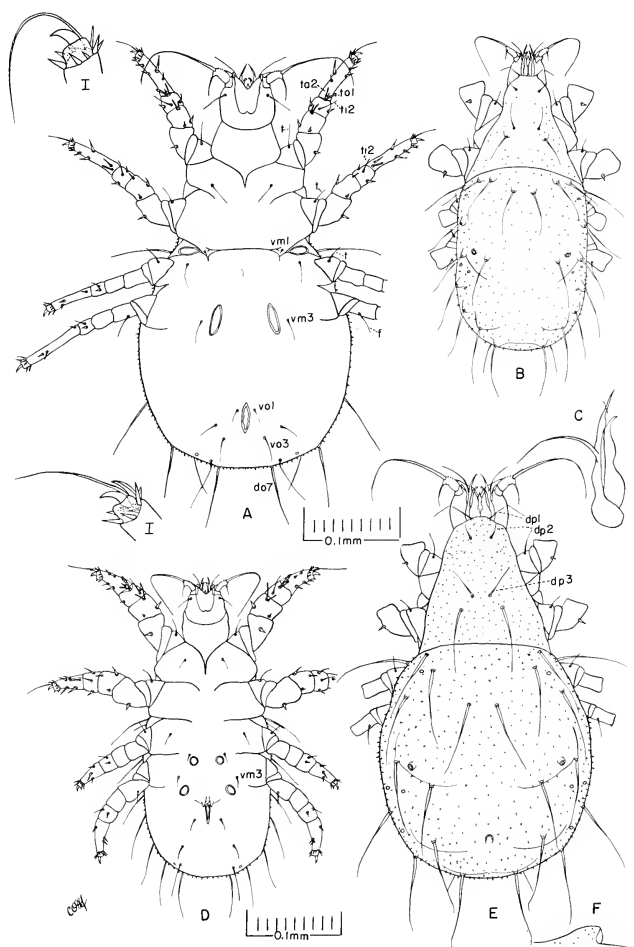


Plate 24—*Histiostoma fimetarium*. A — female, venter. B — male, dorsum. C — chelicera. D — male, venter. E — female, dorsum. F — bursa copulatrix.

*Male*. — No information.

*Deutonymph*. — (Plate 25). Length 0.140 mm.; width 0.103 mm. *Venter*. — Fused pedipalps broad at base, equal to tarsus II; pedipalpal setae equal to fused pedipalps. Sternum *st1* and apodemata *a2* free; *a4* continuous in midline with *st2*; discs *di1* and *di2* slightly smaller than *di3*. *Dorsum*. — Hysterosoma granular or pitted in mid-region. Propodosomal setae not clear to Vitzthum but probably short, thick bristles. Hysterosomal setae *dm1*, *dm2*, and *do1* nearly equal and over one-half length of hysterosoma; remainder nearly equal and shorter than *dm1*. *Legs*. — Seta *ta16* leg I spoon-shaped; *ta16* leg II lancet-shaped; *ta16* legs III-IV long and tapering.

*Remarks*. — This species is based on a single specimen. Many details are lacking, including leg and dorsal setae.

*Collections*. — Found in insect material by H. Wichmann; collected by von Koltze on *Ips subelongatus* Motschulski, from Nikolajewsk on the mouth of the Amur.

*Types*. — One specimen in Vitzthum's collection.

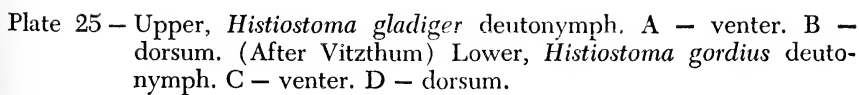
*Histiostoma gordius* (Vitzthum), 1923, new combination

(Plates 25, 26)

*Anoetus gordius* Vitzthum, 1923

*Female*. — (Plate 26). Length 0.300 mm.; width 0.167 mm. *Venter*. — Chelicera not serrated, distally divided into three parts; median process of chelicera also distally divided into three parts; flagellum nearly twice as long as *H. julorum*. Seta *pp1* fine, three times longer than *pp2*. Setae generally shorter and less flexible than in *H. julorum*, otherwise similar, except: *vm1* extremely minute; *vm3* antero-laterad of *r2*; *vo1* larger; *vo2* extremely fine; *vo3* equal to *vo1*; *do7* in a more ventral position. Ringlike structures slightly smaller but similar in shape and position to *H. julorum*. *Dorsum*. — Dorsum granular; rostrum and anterior-lateral margin of propodosoma sculptured. Seta *dp1* smaller than in *H. julorum*, *do7* ventral in position; other setae similar in size and arrangement. Bursa copulatrix on a level with seta *do4*, is only slightly raised, and opens posteriorly. *Legs*. — Trochanter setae, legs I-III are slightly shorter than in *H. julorum*; *ti2* legs I-II slightly longer; other setae generally the same.

*Male*. — (Plate 26). Length 0.240 mm.; width 0.126 mm. *Venter*. — Gnathosoma as in female. Apodeme formed by *a2* and *a3*, and sternum formed by *a1* nearly meet in midline. The ringlike structures are round or



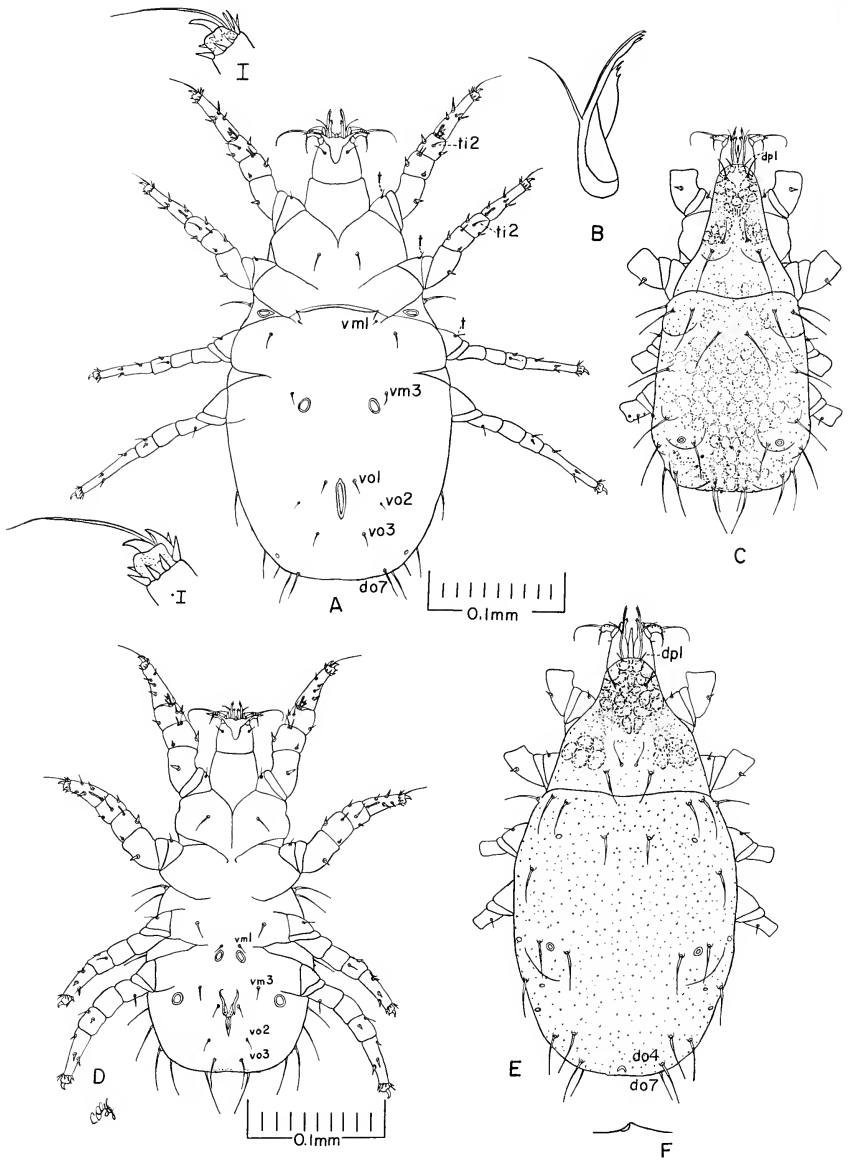


Plate 26 — *Histiostoma gordius*. A — female, venter. B — chelicera. C — male, dorsum. D — male, venter. E — female, dorsum. F — bursa copulatrix.

oval; *r2* widely separated, on level with external genitalia. Setae generally similar to *H. julorum* except: *vm3* antero-mesial of *r2*; *vo2* and *vo3* shorter. *Dorsum*. — Granular and heavily sculptured, especially on the rostrum, antero-lateral region of the propodosoma, and mid-region of hysterosoma. Except for setae *dpl* which are shorter, the dorsal setae are generally the same as in *H. julorum*. Pit-like structures not observed, perhaps because of heavy sculpturing. Bosses conspicuous. *Legs*. — Except for typical male robustness, details of legs essentially similar to female.

*Deutonymph*. — (Plate 25). Length 0.140 mm.; width 0.106 mm. *Venter*. — Fused pedipalps equal to genu I; *ppl* longer than tarsus II. Apodemata *a2* and sternum *st1* nearly touching strongly united apodemata *a4*; sternum *st2* meets *a4*; *st3* and *st4* faintly continuous. *Dorsum*. — Hysterosoma pitted, especially near lateral margins; anterior margin transversely striated; propodosoma smooth except for a single line of transverse sculpturing. Propodosomal setae hairlike, about one-half length of typical hysterosomal setae; *do4* and *do6* short, hairlike; other hysterosomal setae longer than tarsus I, finely tapering and flexible. *Legs*. — Legs similar to *H. julorum*, except: generally smaller; femur I and genu I broader; seta *f* leg I longer; *f* leg II shorter; *f* leg IV shorter.

*Remarks*. — The combination of female characteristics most useful in identifying this species is: non-serrated chelicera, relative lengths of pedipalpal setae, position of *vm3*, position and size of *r1* and *r2*, granular dorsum, and the antero-lateral sculpturing. In addition to the above, the male is distinctive for hysterosomal sculpturing. Deutonymph is distinctive because of the presence of eight pairs of long setae, pitted hysterosoma, and arrangement of apodemata. This species is arrhenotokous. Two "varieties" have been collected: "Florida" described above; "Virginia," differing from "Florida" by lack of sculpturing on antero-lateral margin of hysterosoma in female, and in the male by having seta *vm1* laterad instead of antiad of *r1*.

*Collections*. — "Florida variety": Collected by H. Wichmann on *Ips proximus* Eichhorn and *Ips laricis* Fabricus in Tirol, on the Thaya in Niederosterreich and Mokre in Bosnien, Feb. and May, 1914, and May, 1921; by R. D. Hughes in compost near Ellerson, Va., Oct., 1951 and in woods near Palmetto, Fla., Jan., 1954. "Virginia variety": Collected by R. D. Hughes in Chickahominy Swamp, Aug., 1954.

*Types*. — Holotype in Vitzthum's collection. Plesiotypes (supplied by present authors) as follows:

U. S. National Museum, Washington, D. C.

British Museum of Natural History, London, England

Rijksmuseum van Natuurlijke Historie, Leiden, Netherlands

Museum National d'Histoire Naturelle, Paris, France  
The South Australian Museum, Adelaide, South Australia  
Natal Museum, Pietermaritzburg, Union of South Africa  
National Collection, Ottawa, Canada.  
USSR Academy of Science, Moscow and Leningrad, USSR  
Musée Royal d'Histoire Naturelle de Belgique, Brussels, Belgium

*Histiostoma himalayae* (Vitzthum), 1923, new combination

(Plates 27, 28)

*Anoetus himalayae* Vitzthum, 1923.

*Female*. — (Plate 27). Length 0.360 mm.; width 0.230 mm. *Venter*. — Chelicera with three minute lobes distally and ending in a bristle; median process similar, but smaller; flagellum same length as *H. julorum*. Seta *pp1* half length of *pp2*; pedipalpal membranous structure extends beyond pedipalp. Ringlike structure *r2* oval or nearly round, lying antero-laterad of anus. Setae generally shorter than in *H. julorum*, otherwise similar except *vm3* is antero-laterad of *r2*; *vo1* longer; *vo2* extremely minute; *vo3* one-half length; *do7* ventral. *Dorsum*. — Smooth except for faintly granular rostrum. Setae generally similar in arrangement to *H. julorum*, but generally shorter. Bursa copulatrix is a raised tube-like structure. *Legs*. — Similar to *H. julorum*, except: seta *t* legs I-III minute; seta *f* leg IV shorter; *ti2* legs I-II longer.

*Male*. — (Plate 27). Length 0.300 mm.; width 0.160 mm. *Venter*. — Gnathosoma as in female. Ringlike structures nearly round; *r2* laterad of anus. Setae generally shorter than *H. julorum*; *vm3* antero-mesial of *r2*. *Dorsum*. — Smooth except for slightly granular rostrum. Setae generally shorter than *H. julorum*. *Legs*. — Setae size and pattern similar to female; legs slightly heavier.

*Deutonymph*. (Plate 28). Length 0.172 mm.; width 0.124 mm. *Venter*. — Fused pedipalps equal to genu I; seta *pp1* slightly longer than tarsus II. Base of gnathosoma from which fused pedipalps arise, bulbous and extending anteriorly. Sternum *st1* free; *a2* nearly touching *a4*; *a4* distinctly continuous in midline; *st2* faintly continuous with *a4*; discs *di1*, *di2*, and *di3* equal in size. *Dorsum*. — Smooth except faint transverse sculpturing on propodosoma and transverse striations on anterior margin of hysterosoma. Seta *dp4* equal to genu I, and one-half the length of *dp3*; *do4* and *do6* one-half length of *dp4*; other hysterosomal setae long, hairlike, and nearly equal to *dp3*. *Legs*. — Setae arrangement similar to *H. julorum* except: setae *f* legs I-II much longer; *f* leg IV shorter.



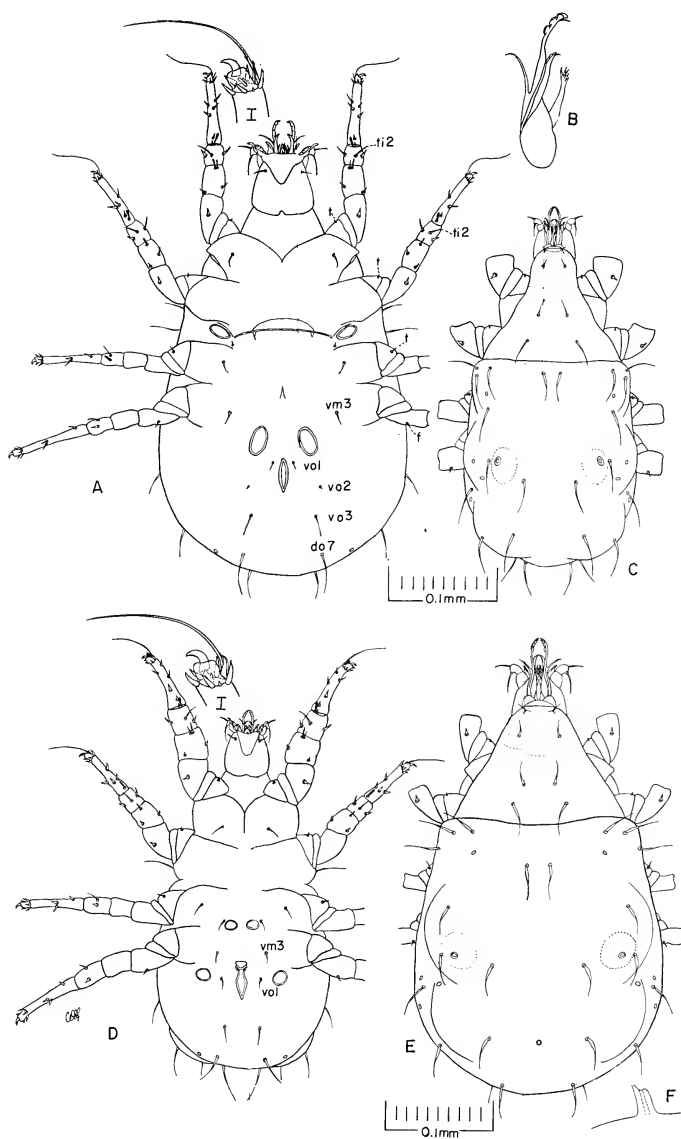


Plate 27 — *Histiostoma himalayae*. A — female, venter. B — chelicera. C — male, dorsum. D — male, venter. E — female, dorsum. F — bursa copulatrix.

*Remarks.* — The combination of characteristics most useful in identifying this species is: lobed chelicera; *pp2* longer than *pp1*; unusual position of *r2* in female; enlarged pedipalpal base and long hairlike setae on dorsum of deutonymph. This species is arrhenotokous. Our deutonymph appears to differ from Vitzthum's figure and description in the number of long, dorsal setae, size of coxal and suctorial plate discs, and the length of *ta3 leg I*. Vitzthum states that the dorsal setae are easily overlooked and that it is difficult to determine the disc size.

*Collections.* — Collected by H. Wichmann on *Polygraphus minor* Stebbing, *Ipiden* collection from Bawar-Range, Jaunsar Makrata, Himalaya, Sept. 1912; by G. S. Foresman in woods, Bluefield, W. Va., June 1950; by R. D. Hughes in woods near Ellerson, Va., July 1950, Aug. 1950; by C. O. Goode in woods by lake, University of Richmond, Va., Oct. 1950; by R. D. Hughes in Smoky Mountains, Norris Dam, Tenn., July 1951; by E. C. Nelson in woods 5 miles east of Mechanicsville, Va., Sept. 1951; by R. D. Hughes in compost, near Ellerson, Va., Oct. 1951; by R. D. Hughes in Chickahominy Swamp, near Ellerson, Va., Oct. 1951; by Mr. Blood in orange grove, Lantana, Fla., Dec. 1951; by R. D. Jones in swamp, Woodlawn, Va., June 1952; by R. D. Hughes under plum trees, near Ellerson, Va., Aug. and Sept. 1952; by R. D. Hughes in Chickahominy Swamp, near Ellerson, Va., Aug. 1954.

*Types.* — Holotype in Vitzthum's collection. Plesiotypes (supplied by present authors) as follows:

U. S. National Museum, Washington, D. C.

British Museum of Natural History, London, England

Rijksmuseum van Natuurlijke Historie, Leiden, Netherlands

Museum National d'Histoire Naturelle, Paris, France

The South Australian Museum, Adelaide, South Australia

Natal Museum, Pietermaritzburg, Union of South Africa

National Collection, Ottawa, Canada

USSR Academy of Science, Moscow and Leningrad, USSR

Musee Royal d'Histoire Naturelle de Belgique, Brussels, Belgium

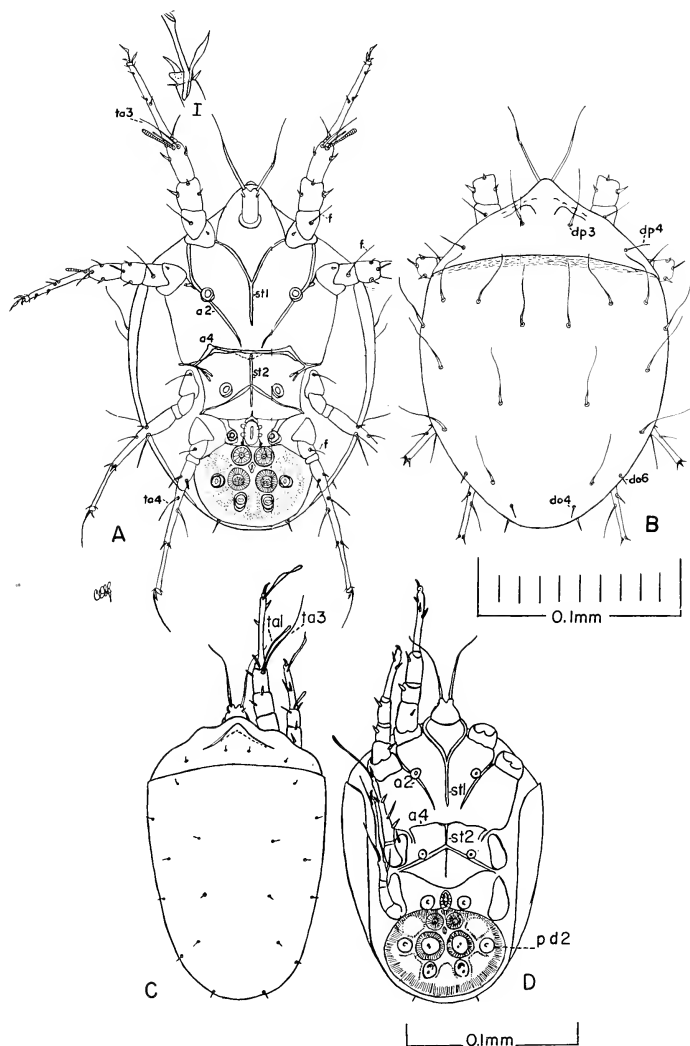


Plate 28 — Upper, *Histiostoma himalayae* deutonymph. A — venter. B — dorsum. Lower, *Histiostoma indicus* deutonymph. C — dorsum. D — venter. (Original unpublished drawing by A. C. Oudemans)

*Histiostoma humiditatis* (Vitzthum), 1927

(Plate 29)

*Anoetus humiditatis* Vitzthum, 1927; *Histiostoma humiditatis* (Vitzthum), 1927 [Womersley, 1942].

*Female*. — (Plate 29). Length 0.390 mm.; width 0.240 mm. *Venter*. — Chelicera very finely serrated, bearing approximately 20 equal teeth, and ending in a spinous process; median process toothed; flagellum twice the length of *H. julorum*. Seta *pp1* twice the length of tarsus I, 6 times as long as *pp2*, finely tapering, and flexible. Ringlike structure *r2* distinctly elongated. Setae generally shorter than *H. julorum*. Seta *vo3* equal to *vo2*; *vm3* median to *r2*; *do7* ventral. *Dorsum*. — Dorsum finely granular and sometimes with minute projections giving a fuzzy appearance; rostrum faintly sculptured. Setae generally smaller than *H. julorum*; *dp1* and *dp2* minute. Bursa copulatrix raised, heavily granular, opens anteriorly and on level with *do3*. *Legs*. — Similar to *H. julorum*, except: seta *ta2* leg I longer; setae *t* legs I-II shorter.

*Male*. — This species is thelytokous.

*Deutonymph*. — (Plate 29). Length 0.140 mm.; width 0.100 mm. *Venter*. — Fused pedipalps longer than tibia I; *pp1* nearly equal to tarsus II. Sternum *st1* free; apodemata *a2* continuous with *a4*; *a4* faint membranous portion connected in midline and joining *st2*. Discs *di1*, *di2*, and *di3* nearly equal. *Dorsum*. — Smooth except for single line of transverse sculpturing on propodosoma, and faint transverse striations on anterior margin of hysterosoma. Setae minute, hairlike, and equal. *Legs*. — Similar to *H. julorum* except: seta *ta3* leg I twice length.

*Remarks*. — The combination of female characteristics most useful in identifying this species is: finely serrated chelicera, long finely tapering *pp1*, elongated *r2*, and position of *vm3* mesiad of *r2*. Deutonymph difficult to distinguish from *H. bakeri* and *H. feroniarum*. What Womersley describes as the male of this species is, in reality, the tritonymph.

*Collections*. — Collected by H. Wichmann on *Agaricus melleus* in moist pine needles, Niederoesterreich, Thaya, Lower Austria, June 1923; by S. L. Allen on the roots of tomato plants grown in nutrient solution, Ryde, New South Wales, Sept. 1941; by R. D. Hughes in Chickahominy Swamp, near Ellerson, Va., Oct. 1951; by R. D. Hughes near Ellerson, Va., July 1952; by A. H. O'Bier north of River Road, 9 miles west of Richmond, Va., Oct. 1954; by R. D. Hughes near Ellerson, Va., Oct. 1955, Dec. 1955.

*Types*. — Holotype in Vitzthum's collection. Plesiotypes (supplied by

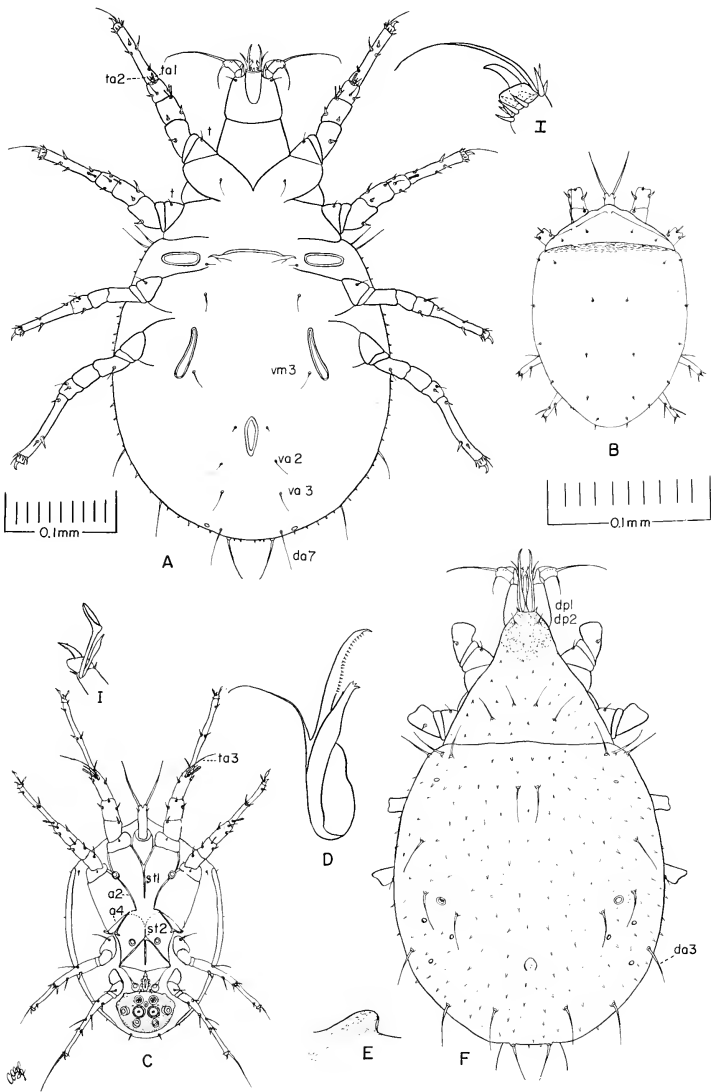


Plate 29 — *Histiostoma humiditatis*. A — female, venter. B — deutonymph, dorsum. C — deutonymph, venter. D — chelicera. E — bursa copulatrix. F — female, dorsum.

present authors) in U. S. National Museum, Washington, D. C. Plesiotypes in author's collection.

*Histiostoma indicus* (Oudemans), 1911

(Plate 28)

*Anoetus indicus* Oudemans, 1911; *Histiostoma indicus* (Oudemans), 1911 [Buitendijk, 1945].

*Female*. — No information.

*Male*. — No information.

*Deutonymph*. — (Plate 28). Length 0.160 mm.; width 0.110 mm. *Venter*. — Fused pedipalps equal to genu I, with broad base and tapering anteriorly; seta *pp1* equal to tarsus I. Sternum *st1* and apodeme *a2* free; *a4* continuous in midline and united with *st2*. Discs *di1* and *di2* smaller than *di3*; *di3* equal to disc *pd2*. *Dorsum*. — Smooth; propodosoma with pointed elevation; anterior margin of propodosoma undulating. Setae minute, hairlike, and equal. *Legs*. — Seta *ta16* legs I-III spatulate; *ta16* leg IV four times the length of the claw and tapering. Leg I seta *ta1* two-thirds length of tarsus I; *ta3* longer than tarsus I.

*Remarks*. — Outstanding features are the terminal tarsal setae legs I-III, the shape of the gnathosoma, and the long *ta1* and *ta3* leg I. One dorsal seta and a few leg setae are not shown in Oudemans' figures.

*Collections*. — One specimen on a blattid with hard abdomen, collected by D. MacGillavry in Banjoewang, Java, 1910.

*Types*. — Holotype in Oudemans' collection.

*Histiostoma insularis* (Oudemans), 1914, new combination

(Plate 30)

*Anoetus insularis* Oudemans, 1914

*Female*. — No information.

*Male*. — No information.

*Deutonymph*. — (Plate 30). Length 0.170 mm.; width 0.110 mm. *Venter*. — Fused pedipalps narrow, equal to genu I; seta *pp1* equal to tarsus II. Sterna *st1* and *st2*, and apodemata *a2* and *a4* end free in midline. Discs *di1* and *di2* slightly smaller than *di3*. *Dorsum*. — Smooth; setae minute, hairlike and equal. Shape elongated. *Legs*. — Seta *ta1* leg

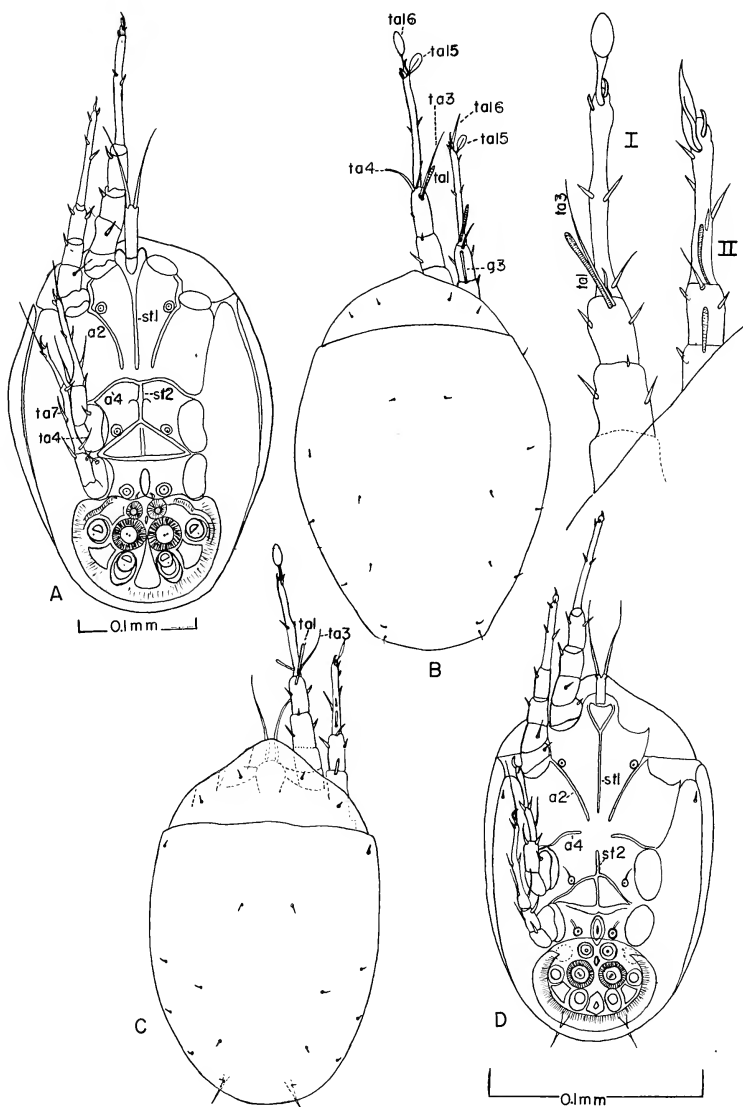


Plate 30 — Upper, *Histiostoma insularis* deutonymph. A — venter. B — dorsum. Right, legs I and II. (After Oudemans) Lower, *Histiostoma litoralis* deutonymph. C — dorsum. D — venter. (After Oudemans)

I one-half as long as tarsus II; *ta3* leg I over one-half length of tarsus I; other leg setae generally similar to *H. julorum*.

*Remarks.* — A few dorsal setae and leg setae are not shown in Oudemans' drawing. (See remarks under *H. feroniarum*) Absence of *ta16* leg III probably an oversight.

*Collections.* — Collected by D. MacGillavry on Terschelling Island, Netherlands, Aug., 1912.

*Types.* — No record.

*Histiostoma lanceocrinus* (Oudemans), 1914

(Plate 31)

*Anoetus lanceocrinus* Oudemans, 1914; *Histiostoma lanceocrinus* (Oudemans), 1914 [Buitendijk, 1945].

*Female.* — No information.

*Male.* — No information.

*Deutonymph.* — (Plate 31). Length 0.162 mm.; width 0.116 mm. *Venter.* — Fused pedipalps equal in length to genu I; pedipalpal setae *pp1* equal to tarsus II. Sterna *st1* and *st2* and apodemata *a2* unite with apodemata *a4* which are continuous in midline; *st2* continuous with *a5*; *st2* with rounded expansion and continuous with *st3*, coxal discs *di1*, *di2*, and *di3* nearly equal. Suctorial plate large; functional suckers *su* nearly as large as *pd1*. *Dorsum.* — Granular; hairlike setae, approximately equal to genu II except for *dm1*, *dm2*, and *do1* which are equal to *pp1*, and saber-shaped; *do4* minute. *Legs.* — Tarsi I-II shorter than *H. julorum*; *ta16* legs I-II spoon-shaped; seta *ta4* leg IV short; other characteristics generally the same as *H. julorum*.

*Remarks.* — Two dorsal setae and a few leg setae are not shown on Oudemans' drawing. Features most useful in identifying this species are length of pedipalps and *pp1*, arrangement of apodemata, large suctorial plate, granular dorsum, saber-shaped dorsal setae, spoon-shaped *ta16* legs I-II and length of *ta3* leg I.

*Collections.* — Collected by D. MacGillavry, Wijk aan Zee, Netherlands, July, 1911.

*Types.* — Holotype in Oudemans' collection.



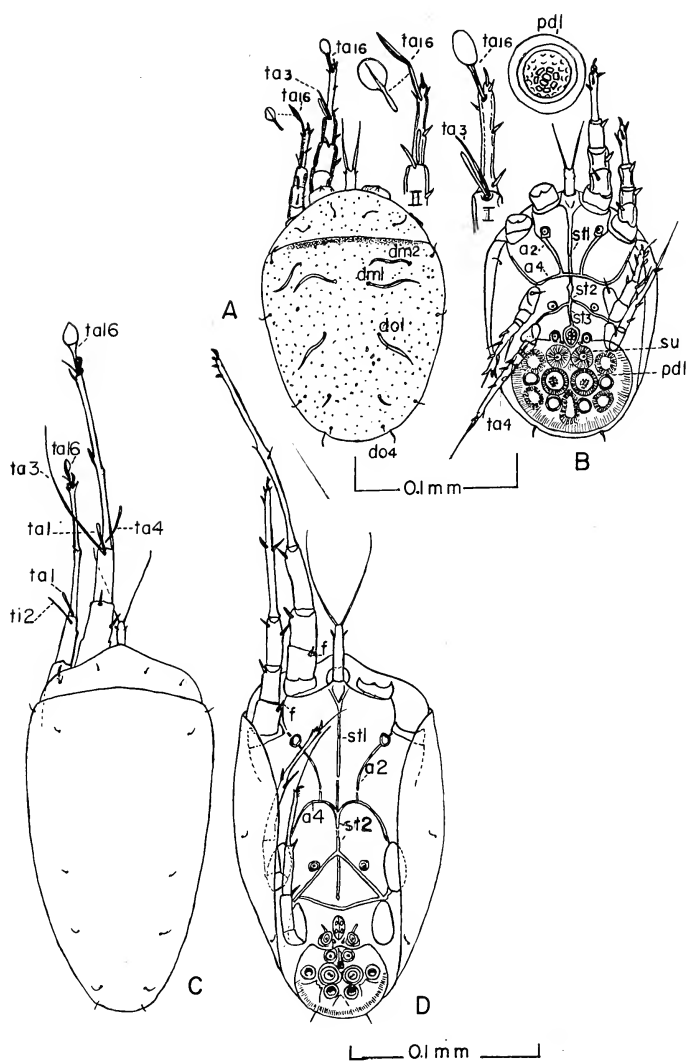


Plate 31 — Upper, *Histiostoma lanceocrinus* deutonymph. A — dorsum. B — venter. (Original unpublished drawings by A. C. Oudemans) Lower, *Histiostoma longipes* deutonymph. C — dorsum. D — venter. (Original unpublished drawing by Oudemans)

*Histiostoma litoralis* (Oudemans), 1914

(Plate 30)

*Anoetus litoralis* Oudemans, 1914; *Histiostoma litoralis* (Oudemans), 1914 [Buitendijk, 1945].

*Female*. — No information.

*Male*. — No information.

*Deutonymph*. — (Plate 30). Length 0.320 mm.; width 0.221 mm. *Venter*. — Fused pedipalps equal in length to tibia I; pedipalpal setae *pp1* approximately two-thirds the length of tarsus I. Sternum *st1* and apodemata *a2* end free; *a4* and *st2* unite in mid-line; fine hairlike extensions arise from *st2*. Discs *di1* and *di2* slightly smaller than *di3*. *Dorsum*. — Smooth; setae minute, hairlike, and equal. *Legs*. — Leg I tarsi I-II long, nearly equal; setae *ta15-16* spoon-shaped, one-half length of tarsus I; *ta4* slightly longer than *ta1*. Leg II seta *ta16* tapering, *ta15* spoon-shaped, *g3* equal to *ta1*, setae *ta4* and *ta7* leg IV shorter than *H. julorum*.

*Remarks*. — Assuming Oudemans' measurements to be correct, the deutonymph of this species is the largest in the family Anoetidae. Two dorsal setae and a few leg setae are not shown on Oudemans' drawing. Oudemans shows seta *g3* leg II as striated. This is probably incorrect. Features most useful in identifying this species are the length of pedipalps and *pp1*, arrangement of apodemata, smooth dorsum, minute dorsal setae, length of *ta2* leg I, spoon-shaped *ta15* legs I-II and spoon-shaped *ta16* leg I, tapering *ta16* leg II.

*Collections*. — Collected by D. MacGillavry, Tershelling Island. Aug., 1912.

*Types*. — Holotype in Oudemans' collection.

*Histiostoma longipes* (Oudemans), 1911

(Plate 31)

*Anoetus longipes* Oudemans, 1911; *Histiostoma longipes* (Oudemans), 1911 [Buitendijk, 1945]; *Anoetus brevipes* Oudemans, 1911.

*Female*. — No information.

*Male*. — No information.

*Deutonymph*. — (Plate 31). Length 0.177 mm.; width 0.100 mm.

*Venter.* — Fused pedipalps narrow, equal to tibia I, pedipalpal base small; seta *pp1* nearly equal to genu I plus tibia I. Sternum *st1* and apodemata *a2* faintly connected to *a4*; apodemata *a4* distinctly arched and joined to *st2* in midline. Coxal discs *di1* on *a2* equal in size to *di2-di3*. *Dorsum.* — Smooth, setae minute, hairlike, and equal. Lateral margins of hysterosoma distinctly folded ventrally. *Legs.* — Tarsus I over twice as long as *pp1*; *ta16* spoon-shaped; *ta3* three-fourths length of tarsus I; *ta4* longer than *ta1*; *f* spine-like. Tarsus II two-thirds length of tarsus I; seta *ta16* lancet-shaped, *ti2* longer than *ta1*, *f* spine-like; legs III-IV similar to *H. julorum* except fewer long setae.

*Remarks.* — Features most useful in identifying this species are as follows: shape of fused pedipalps, length of *pp1*, arrangement of apodemata, smooth dorsum with short equal setae, extremely long tarsus I and elongated *ta3* leg I. Another variety of this species was collected from the same blattid which Oudemans calls the *brevipes* form of *A. longipes*. The two "varieties" are the same except *brevipes* has a shorter body, less foldings on the margin of the hysterosoma, larger propodosoma, shorter leg I, shorter seta *ta3* leg I, tapering *ta16* leg II. With the possible exception of the relative difference in size of leg I of the two specimens examined by Oudemans, it is doubtful that the differences noted above are of sufficient magnitude to justify the establishment of the variety *brevipes*. Individual differences of type and magnitude as those listed have often been observed in other species in which large numbers of specimens were available for study. The method of mounting the specimen may account for some of these differences. Oudemans suggests that the difference between the two specimens he studied are of different sexes. This is almost certainly not the case since careful studies of nymphal forms in other species with this point in mind have invariably shown that both primary and secondary characteristics do not become evident until the adult stage. A few dorsal and leg setae have been omitted in Oudemans' drawing.

*Collections.* — Collected by D. MacGillavry on a blattid with hard abdomen, Banjoewangi, Java, 1910.

*Types.* — Holotype in Oudemans' collection.

*Histiostoma lorentzi* (Oudemans), 1905

(Plate 32)

*Anoetus lorentzi* Oudemans, 1905; *Histiostoma lorentzi* (Oudemans), 1905 [Womersley, 1941.]

*Female.* — No information.

*Male.* — No information.

*Deutonymph.* — (Plate 32). Length 0.200 mm.; width 0.145 mm. *Venter.* — Fused pedipalps wide at base and slightly longer than tibia I; pedipalpal setae *pp1* equal to tarsus II; pedipalpal base small. Sternum *st1* continuous with *a4*; *a2* nearly touching *a4*; apodemata *a4* join mesially to form a straight, bar-like structure; *st2* faintly continuous with *a4* and *a5*. *Dorsum.* — Anterior margin of propodosoma concave. Dorsum pitted; anterior margin of hysterosoma transversely striated. Setae variable in length; propodosomal setae equal and slightly longer than tibia II; *dm1* heavier and equal to *pp1*; *do1* nearly twice as long as propodosomal setae; *dm2* equal to propodosomal setae; all other dorsal setae hairlike and equal to or slightly shorter than tibia II. *Legs.* — Tarsus I nearly half length of soma, seta *ta16* elongated leaf-shaped, *ta2* and *ta3* nearly equal, one-half length of tarsus I, *ta4* tapering and longer than *tal*, *g3* equal to *ta4*; leg II seta *ta16* tapering, *ti1* thorn-like, *ti2* hairlike; legs III-IV similar to *H. julorum* except shorter setae *ta16*.

*Remarks.* — Features useful in identifying this species are shape of fused pedipalps, length of *pp1*, arrangement of apodemata, pitted dorsum, shape of propodosoma, heavy band of transverse striations, two pairs of longer dorsal setae, exceptionally long tarsus I, *ta2* and *ta3* nearly equal, and *ta16* leg I leaf-shaped, *ta16* leg II tapering. A few leg setae are not shown in Oudemans' drawing.

*Collections.* — Fourteen specimens on a coccinellid in decaying leaves, Cyclope Mountains, New Guinea, April 13, 1903. Collected by Messrs. de Beaufort and Lorentz.

*Types.* — Holotype in Oudemans' collection.

*Histiostoma maritimus* (Oudemans), 1914

(Plate 32)

*Anoetus maritimus* Oudemans, 1914; *Histiostoma maritimus* (Oudemans), 1914 [Buitendijk, 1945].

*Female.* — No information.

*Male.* — No information.

*Deutonymph.* — (Plate 32). Length 0.175 mm.; width 0.118 mm. *Venter.* — Fused pedipalps slightly longer than tibia I; *pp1* equal to tarsus II. Sternum *st1* free; apodemata *a2* barely joining apodemata *a4*, latter united in midline; *st2* short and united with *a5*; *st3* and *st4* continuous. Coxal discs *di2* slightly smaller than *di1* and *di3*. *Dorsum.* —

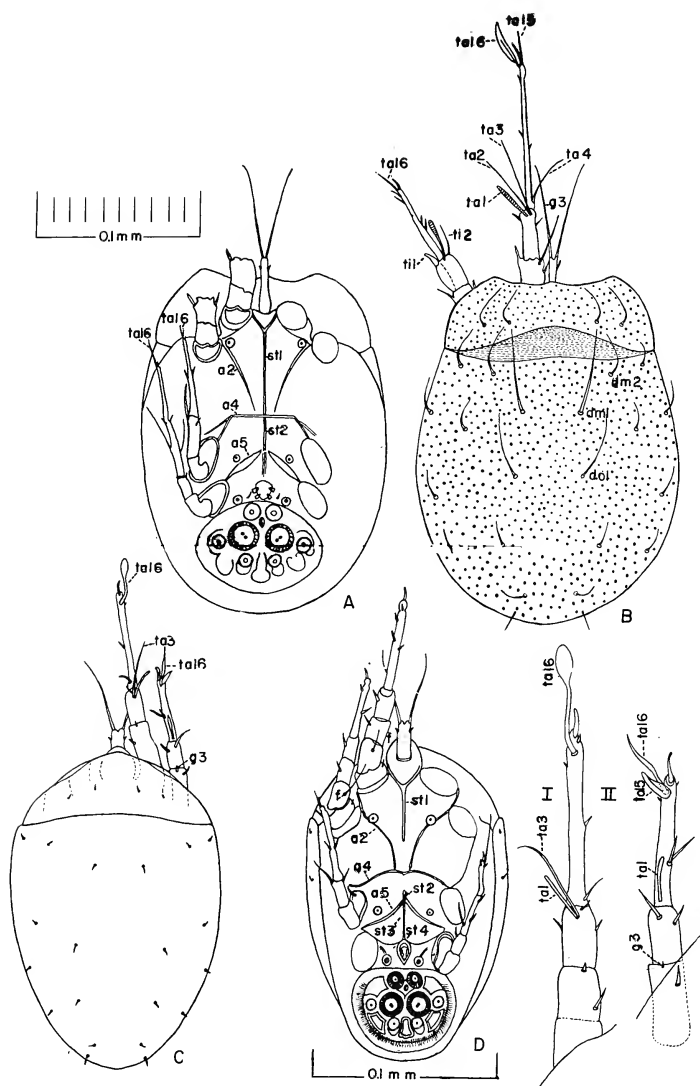


Plate 32 — Upper, *Histiostoma lorentzi* deutonymph. A — venter. B — dorsum. (After Oudemans) Lower, *Histiostoma maritimus* deutonymph. C — dorsum. D — venter. Right, legs I and II. (After Oudemans)

Smooth, setae minute, hairlike, and equal in length. Pedipalpal base projects slightly beyond the propodosoma. *Legs*. — Seta *ta16* leg I spoon-shaped, *ta3* one-half the length of tarsus I, femoral seta equal to genu I; leg II seta *ta16* lancet-shaped, *g3* very short, and seta *f* longer than in *H. julorum*.

*Remarks*. — The lancet-shaped seta *ta15* leg I was not observed by Oudemans and is either missing or is extremely small. A few leg setae are not shown on Oudemans' drawings. Features useful in identifying this species are: shape of fused pedipalps, length of *pp1*, arrangement of apodemata, size of coxal discs, smooth dorsum with minute setae, length of *ta2* leg I, *ta16* leg I spoon-shaped, and *ta16* leg II lancet-shaped.

*Collections*. — Collected by D. MacGillavry, Terschelling Island, August, 1912.

*Types*. — Holotype in Oudemans' collection.

*Histiostoma murchiei*, sp. nov.

(Plates 33-35)

*Female*. — (Plates 33, 34). Length 0.620 mm.; width 0.420 mm. *Venter*. — The entire gnathosoma of a gravid female is extremely small in comparison with the idiosoma and smaller than *H. julorum*. Chelicera smooth except for three minute terminal hook-like processes; cheliceral flagellum fine and equal in length to seta *dp1*; seta *pp1* minute, one-fourth length of tarsus I; *pp2* not observed, therefore missing or extremely minute. Ringlike structures small, circular; *r1* mesiad of *a5*; *r2* mesiad of *a6*. Ventral setae are fine, hairlike and variable in length; only *vo3* is as long as tibia I; seta *do7* is equal to *vo3* and is ventral instead of dorsal or marginal in position. The anus lies approximately in the center of the greatly enlarged opisthosoma. *Dorsum*. — Smooth; setae fine, hairlike; hysterosomal setae nearly equal to tibia I; propodosomal setae nearly equal, one-half length of tibia I. Opisthosoma greatly distended when gravid. Bursa copulatrix not raised, and nearly marginal in position. *Legs*. — The legs appear more fragile and have generally finer or smaller setae than in *H. julorum*. Legs III-IV are somewhat longer than in *H. julorum* with a terminal tarsal seta equal to claw. Leg II with supernumerary seta *ta-x*.

*Male*. — (Plate 35). Length 0.332 mm.; width 0.220 mm. *Venter*. — Gnathosoma small, almost vestigial and generally similar to female. Ringlike structures nearly circular and arranged in a square above the external genitalia. Setae hairlike and slightly variable in length, all approximately one-half the length of tibia I, except *vol* which is slightly

shorter. Opisthosomatic region more elongated than *H. julorum*. *Dorsum*.  
— Smooth; setae fine, hairlike; hysterosomal setae approximately one-half

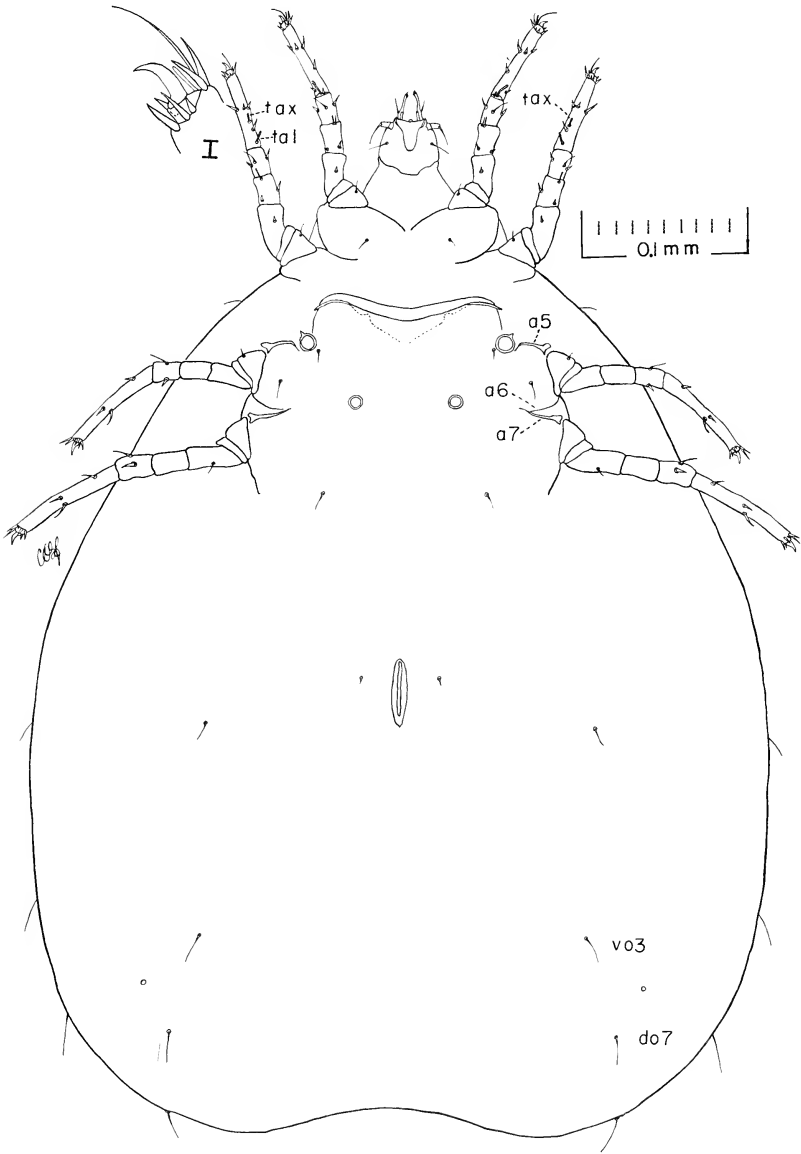


Plate 33 — *Histiotoma murchiei* sp. nov. female, venter.

length of tibia I; propodosomal setae shorter as in female. *Legs.* — All legs conspicuously long and slender, especially legs III-IV which are approximately equal to length of hysterosoma. Leg I setae generally similar to *H.*

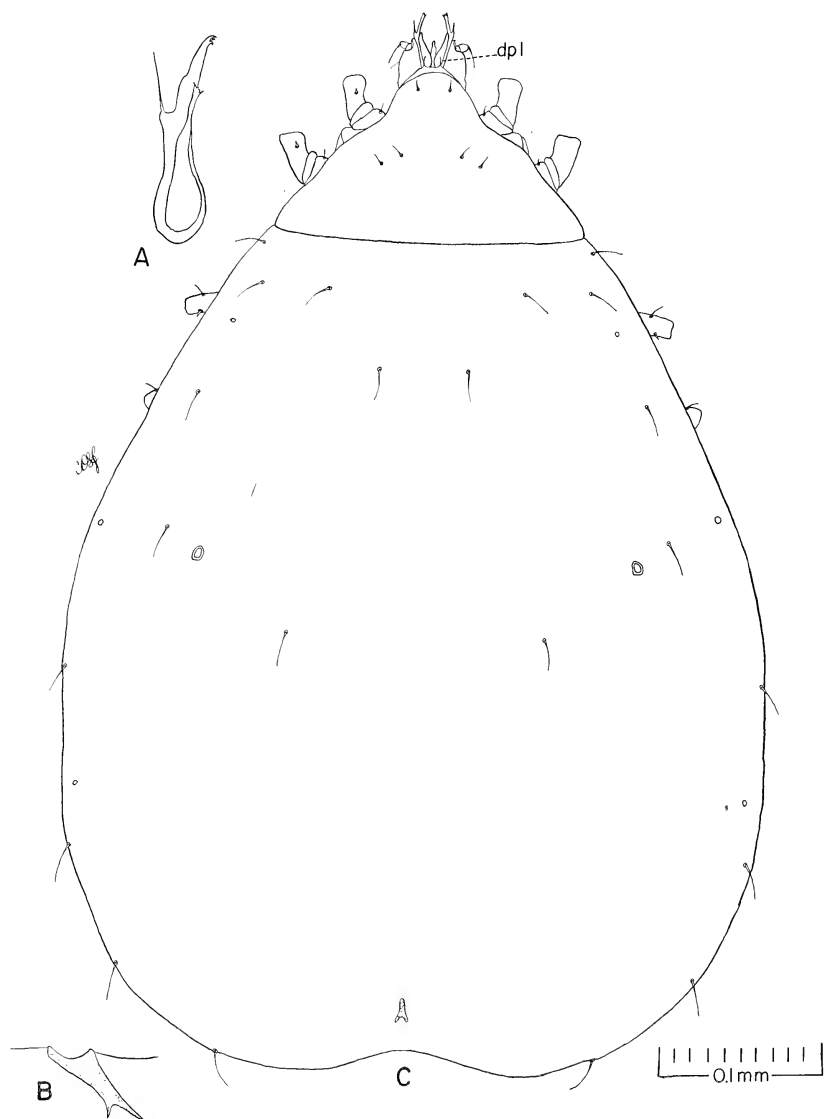


Plate 34 — *Histiostoma murchiei* sp. nov. A — chelicera. B — bursa copulatrix. C — female, dorsum.



*julorum* with the following exceptions; femoral seta smaller, *gl* smaller, *ti2* longer, *ta7* smaller, *ta15* not claw-like, *ta16* shorter. Leg II setae are generally similar to *H. julorum*, except smaller femoral seta, *ta6* and *ta7* smaller, and supernumerary sensory seta *ta-x* similar in size and shape to *ta1*; seta *ta8-ta9* legs III-IV longer than claws. Claws on all legs extremely blunt.

*Deutonymph.* — (Plate 35). Length 0.192 mm.; width 0.140 mm. *Venter.* — Fused pedipalps almost vestigial, length and width equal; seta *pp1* equal to tibia I; *pp2* missing. Sternum *st1* free; apodeme *a2* faintly joined to apodemata *a4* which are continuous in midline; a membranous portion of *a4* faintly joins *st2*. Coxal discs *di1* and *di2* are unusually small; suctorial plate discs *pd2* and *pd3* are slightly larger than *di1*. Functional sucker *su* equal to *pd1*. *Dorsum.* — Dorsum smooth except for transverse sculpturing on the anterior margin of short propodosoma. Setae variable in length; setae *dm1*, *dm2*, *do1* and *do2* are equal to genu I; all other dorsal setae are shorter and nearly equal. *Legs.* — Setae *ta16* legs I-II lancet-shaped; *ta16* legs III-IV tapering, equal and twice length of claw. Leg setae are generally heavier than in *H. julorum*, other features as follows: femoral setae legs I-II more spine-like; leg I *ta1* longer and heavier, *ta3* twice as long, *ta4* twice as long with rounded tip; leg II *ti2* twice as long, *ta1* nearly twice as long and much heavier; *ti1* legs III-IV much heavier.

*Remarks.* — Features especially useful in identifying this species are: extremely small gnathosoma, missing pedipalpal seta *pp2*, greatly enlarged female opisthosoma, small circular ringlike structures *r1* and *r2*, extremely long legs of the male, blunt claws of the male, supernumerary tarsal II seta *ta-x*, nonserrated chelicera. For deutonymph, short fused pedipalps, propodosoma short, small *di1* and *di2*, and thorn-like leg setae. This species is of unusual interest because it is one of the only two species so far described which is semi-parasitic. The other species is *H. berghi* described above. Specimens were collected by W. R. Murchie in August 1954 in cocoons of *Allolobophora chlorotica* and possibly *Allolobophora caliginosa* and *Eisenia rosa*. These collections were made along the shore of the Carp River, Emmet County, Michigan (Township 38 north, Range 4 west, Section 15). In personal communications Dr. Murchie has furnished additional information as follows: the Carp River area where the largest collections were made, is forested and subject to spring floods. Infected cocoons have been collected in the same area for several years prior to 1954, with the percentage of infected cocoons remaining fairly constant throughout this period. Collections have also been made in Shiawassee and Washtenaw counties. The inference is that this species probably has a wide distribution. Host relationships assume greater interest because *A. chlorotica* is presumed endemic to Europe. It is estimated that approximately 45% of *A. chlorotica* cocoons are infected. Over 50 of these co-

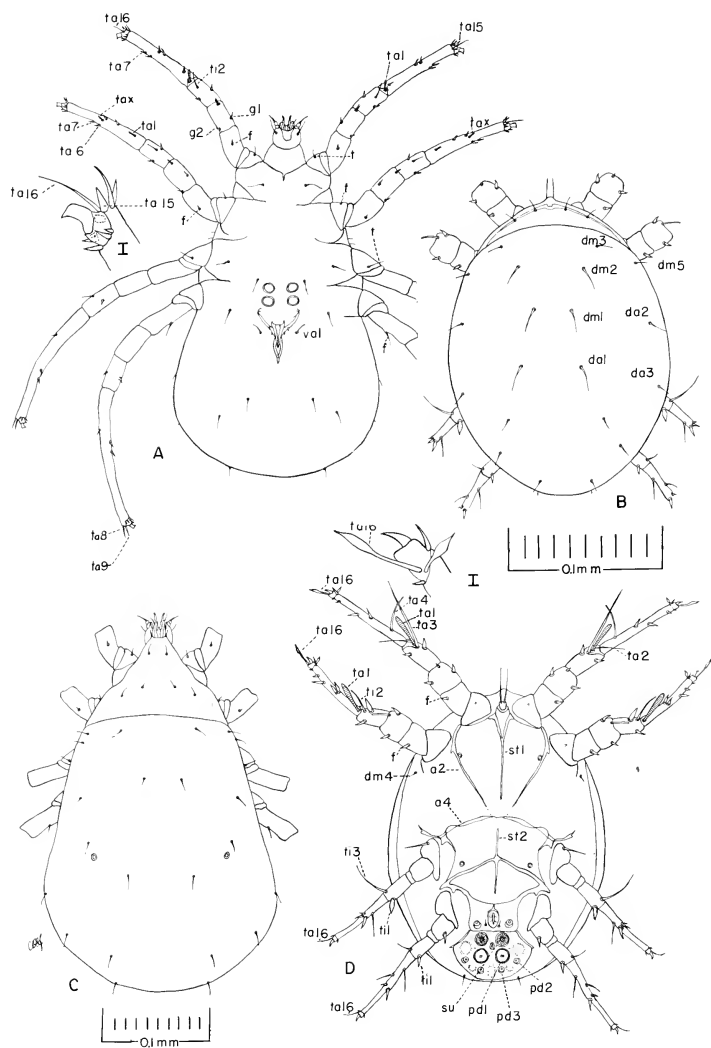


Plate 35 — *Histiostoma murchiei* sp. nov. A — male, venter. B — deutonymph, dorsum. C — male, dorsum. D — deutonymph, venter.

cocoons have been examined by us. In no instance was there an egg, embryo, or immature worm when mites were present. Presumably then, the mites feed on the eggs. Infected cocoons always contain a small number of adults and large numbers of other stages except tritonymphs. The tritonymph of *H. berghi* has atypically stout legs I-II. Jensen believes these stout legs are modified for boring into the cocoons of leeches, and reports an instance in which he thought this to be taking place. Whether or not this is the correct mode of infection by *H. berghi* is open to question since it is based on only one observation. No information is available on the mode of infection of cocoons by *H. murchiei*. Anoetids are generally unarmed surface feeders and it is doubtful that they could penetrate the tough cocoon of an annelid, even with stout legs. A possible mode of infection of cocoons by *H. murchiei* may be as follows: deutonymphs escape from broken or disintegrated cocoons and find their way to the anterior segments of an earthworm, where they become attached. When a cocoon is formed one or more deutonymphs become enclosed and metamorphose into a tritonymph and thence into an adult. Eggs develop to the deutonymph stage in the cocoon but not beyond. That this sequence of events is a probability is supported by the fact that usually only two or three adults are found per cocoon, that no tritonymphs have been found, and that the deutonymph is the typical migratory stage. Attempts to culture this species on stable fly media, which has been found to be suitable culture medium for a large number of other species, have so far failed. *H. berghi* and *H. murchiei* have a number of features in common aside from the fact that they are found in the cocoons of annelids. The females of both species are the largest anoetids so far described, pedipalpal seta *pp2* is missing, gnathosoma is almost vestigial, bursa copulatrix is marginal in position, and arrangement of ringlike discs in males is similar. These features indicate a close relationship. *H. murchiei* is the only anoetid species in which a supernumerary mid-tarsal II seta, designated *ta-x*, has been found. This occurs in both the male and female. It is not known whether this seta is found in *H. berghi* since Jensen omitted a number of typical leg setae from his drawings. This species is named in honor of W. R. Murchie.

*Collections.* — (See under remarks.)

*Types.* — Holotype female, and paratypes in U. S. National Museum, Washington, D. C. Paratypes in authors' collection.

*Histiostoma necrophori* (Dujardin), 1849

(Plate 36)

*Hypopus necrophori* Dujardin, 1849b; *Anoetus necrophori* (Dujardin), 1849 [Oudemans, 1924c]; *Anoetus neglectus* Oudemans, 1903 [Oude-

mans, 1924c]; *Histiostoma necrophori* (Dujardin), 1849 [Oudemans, 1937].

*Female.* — No information.

*Male.* — No information.

*Deutonymph.* — (Plate 36). Length 0.290 mm.; width 0.200 mm. *Venter.* — Fused pedipalps wide at base, equal to genu II; pedipalpal seta *pp1* equal to tarsus II. Sternum *st1* free but close to apodemata *a4*; apodeme *a2* joins with united apodemata *a4*; sternum *st2* is connected to *a4* and *a5*. Functional suckers *su* equal to plate discs *pd1*. Coxal discs *di1* and *di2* large and equal. *Dorsum.* — Dorsum smooth; propodosoma short, and nearly rectangular; setae equal, one-half length of *pp1*. *Legs.* — Seta *ta16* legs I-II spoon-shaped; leg III with spatulate terminal tarsal seta; terminal tarsal seta leg IV longer than the entire leg IV and tapering. Seta *ta3* leg I equal to tarsus II; *ti2* leg II nearly equal to *ta3* leg I; legs III-IV setae generally large.

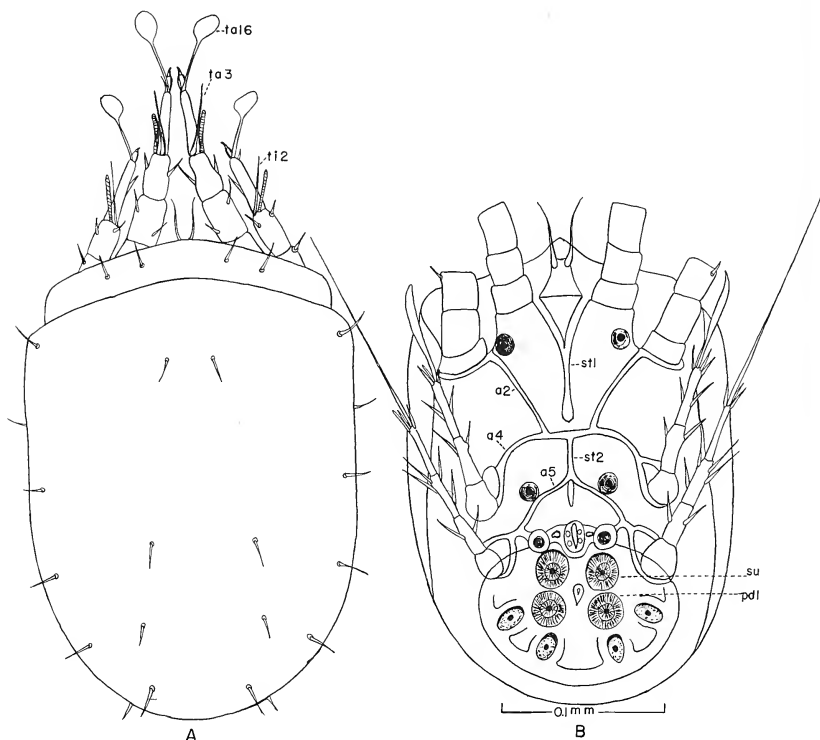


Plate 36 — *Histiostoma necrophori* deutonymph. A — dorsum. B — venter.  
(After Dujardin)

*Remarks.* — Characteristic features of this species which have diagnostic value are as follows: shape of fused pedipalps, length of *pp1*, short propodosoma, spoon-shaped *ta16* legs I-II, and unusual terminal tarsal setae legs III-IV, which may be modified claws as suggested for the fourth leg of *A. laboratorium*. Oudemans' figure of *A. neglectus* has been used.

*Collections.* — Collected by C. Dujardin on the beetle *Necrophorus vespillo*, 1849; by S. A. Poppe on the beetle *Necrophorus humator*, Bremen, Germany, 1902; by Frank A. Turk on *Necrophorus humator* along with a gasmid mite, Great Britain, Feb. 1943.

*Types.* — No record.

*Histiostoma nigrellii* sp. nov.

(Plate 37)

*Female.* — (Plate 37). Length 0.365 mm.; width 0.210 mm. *Venter.* — Chelicera finely serrated with approximately 14 teeth; cheliceral flagellum shorter than toothed portion. Seta *pp1* three times the length of *pp2*. Posterior ringlike structures *r2* elongated. Setae generally shorter than *H. julorum*. Seta *vo1* is equal to *vo2*; seta *vm3* postero-mesial of *r2*; *do7* ventral. *Dorsum.* — Dorsum finely granular and sometimes with minute projections giving a fuzzy appearance; rostrum faintly sculptured. Setae generally shorter than *H. julorum* except for *dp2*. Seta *dp3* distinctly shorter than *dp4*. Bursa copulatrix raised, opens anteriorly and is slightly above a line connecting setae *do5*. *Legs.* — Leg shape and setae size similar to *H. julorum* except *g3*, *g4*, *ta2* and *ti2* leg I longer; leg II seta *ti2* longer; legs III-IV setae *ti1* shorter, seta *ta9* longer than claw.

*Male.* — (Plate 37). Length 0.225 mm.; width 0.120 mm. *Venter.* — Gnathosoma as in female. Anterior ringlike structures *r1* elongated, lying close together above the external genitalia; posterior ringlike structures *r2* slightly elongated, and laterad of anus. Setae variable in length. Position of setae similar to *H. julorum* except: *vm3* anterior of *r2*; *vo2* and *vo3* shorter than *H. julorum*. *Dorsum.* — Dorsum granular, sometimes with fine projections giving fuzzy appearance; rostrum faintly sculptured. Setae generally shorter than *H. julorum* especially *dpl*. Excretory pores distinctly elevated. *Legs.* — Shape and setae arrangement similar to *H. julorum* except: leg I midtarsal setae widely separated, *ta2* and *ti2* longer; leg II *ti2* longer. Claws somewhat heavier than in female, otherwise similar.

*Deutonymph.* — Not observed.

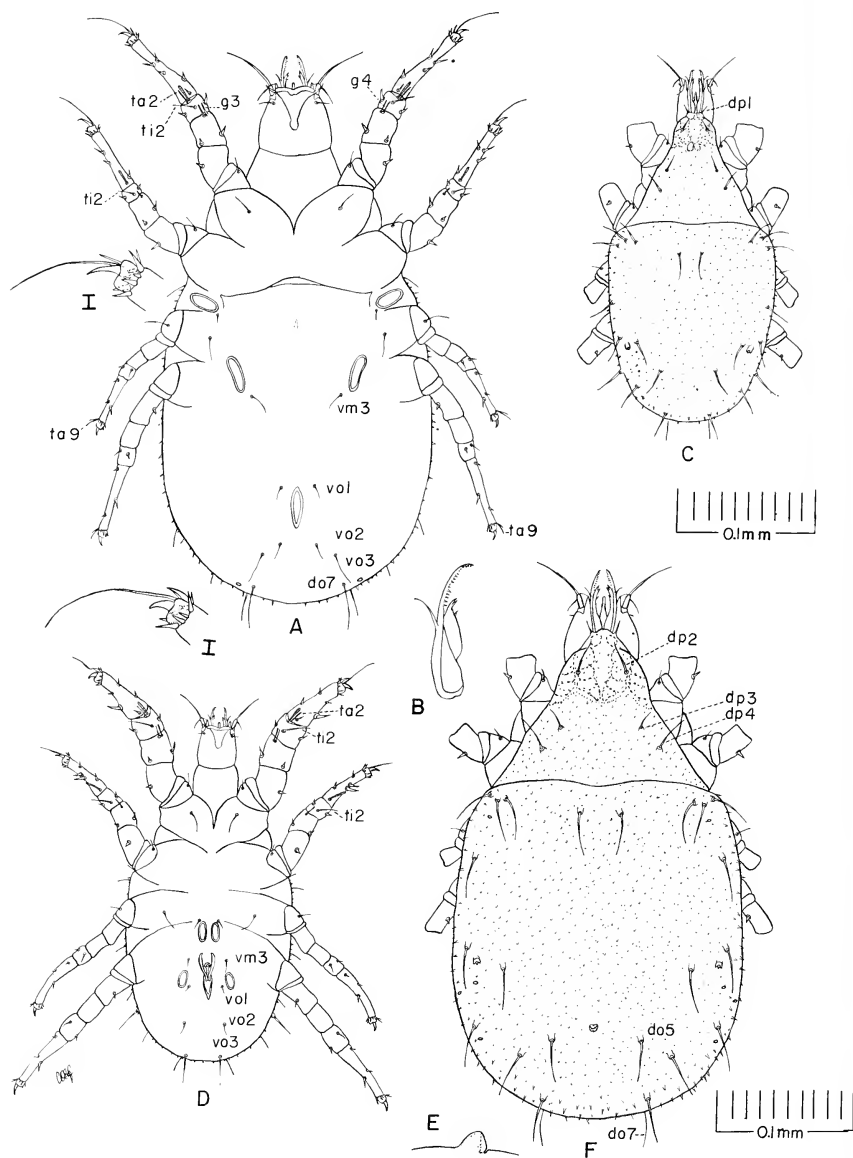


Plate 37 — *Histiostoma nigrellii* sp. nov. A — female, venter. B — chelicera. C — male, dorsum. D — male, venter. E — bursa copulatrix. F — female, dorsum.

*Remarks.* — See remarks on *H. cyrtandrae* above. Only the male and female of this species have been observed. No attempts to culture this species on housefly media were made and the colony was subsequently lost. It is tentatively placed in the genus *Histiostoma* on the basis of the general appearance of the adults. This species is of special interest because it is one of the only two species which has been observed to live completely submerged indefinitely. In this instance it was observed daily over a period of two weeks in water from an aquarium. The combination of adult characteristics most useful in identifying this species is: the finely serrated chelicera, *pp1* of medium length, granular dorsum, claws longer and less curved. For the female: shape of posterior ringlike structures and position of seta *vm3*, arrangement of anal and opisthosomatic setae, position of bursa copulatrix. For the male: position of posterior ringlike structures and setae *vm3* and *vo1*. Named in honor of Ross F. Nigrelli.

*Collections.* — Collected by Ross F. Nigrelli in a goldfish tank at the Aquarium, New York Zoological Society, March 1953.

*Types.* — Holotype and paratypes in authors' collection.

*Histiostoma phyllophorus* (Oudemans), 1905

(Plates 38, 39)

*Anoetus phyllophorus* Oudemans, 1905; *Histiostoma nicholli* Womersley, 1941; *Histiostoma phyllophorus* (Oudemans), 1905 [Buitendijk, 1945].

*Female.* — (Plate 38). Length 0.360 mm.; width 0.215 mm. *Venter.* — Chelicera non-serrated, cheliceral flagellum longer than seta *dp4*; pedipalpal seta *pp1* finely tapering, longer than longest dorsal setae; *pp2* equal to *dp2*. Setae similar to *H. julorum*, except *vm1* shorter; *do7* ventral in position. Posterior ringlike structures elongated and lie on a line with coxa IV. *Dorsum.* — Dorsum sometimes with tiny projections giving a fuzzy appearance; rostrum granular, and faintly sculptured. Setae generally longer than in *H. julorum*. Bursa copulatrix nearly on a line with setae *dol* opening anteriorly on a slight elevation, and with a distinct elevation anterior to the opening. *Legs.* — Setae generally larger than in *H. julorum*, especially *ta1*, *ta2*, *g3* and *g4* of leg I; *ta1* and *g3* of leg II; and *ta5* and *ta7* of legs III-IV. Other differences are: generally longer and heavier terminal tarsal setae surrounding the claw on all legs, longer *ta9* legs III-IV, and especially the unique barb on the end of setae *ta5* legs III-IV.

*Male.* — (Plate 38). Length 0.270 mm.; width 0.120 mm. *Venter.* — Gnathosoma as in female. Posterior ringlike structures slightly elongated,

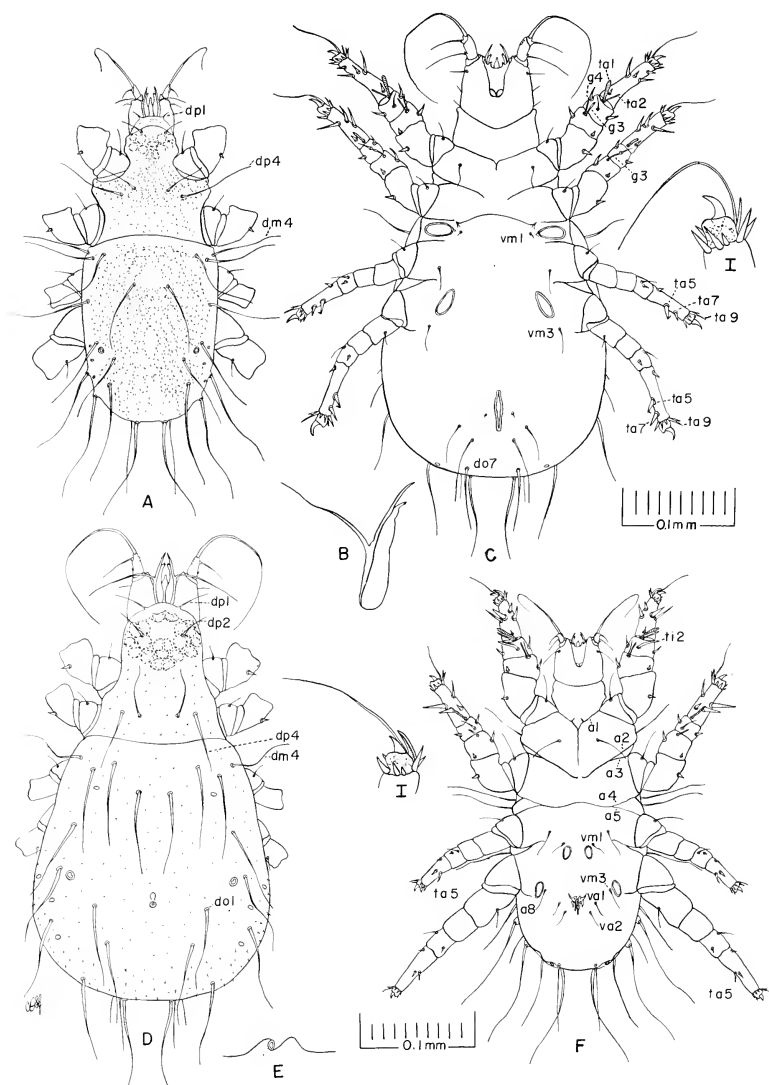


Plate 38 — *Histiotoma phyllophorus*. A — male, dorsum. B — chelicera. C — female, venter. D — female, dorsum. E — bursa copulatrix. F — male, venter.



widely separated and on a line between the genitalia and apodemata *a8*. Setae generally longer than *H. julorum*, except *vo2*. Setae arrangement generally similar except: *vm3* mesiad of *r2*, *vo2* closer to *vo1* and lateral to the posterior end of the anus. The sternum formed by the union of *a1* extends posteriorly close to the united *a2* and *a3* which almost meet in midline; apodemata formed by the union of *a4* and *a5* unite in midline. Anus shortened and nearly obscured by external genitalia. *Dorsum*. — Dorsum differs from female as follows: entire dorsum distinctly sculptured; setae generally finer; *dpl* shorter; *dp4* longer, *dm4* longer, opisthosomatic setae generally longer; pit-like structure *dpi1* not observed. *Legs*. — Setae similar to female except: *ti2* larger and midtarsal setae more massive on leg I; midtarsal seta larger on leg II; setae *ta5* leg III-IV without barb.

*Deutonymph*. — (Plate 39). Length 0.200 mm.; width 0.135 mm. *Venter*. — Fused pedipalps over one-half the length of tarsus I; seta *pp1* longer than tarsus I. Sternum *st1* unites with apodemata *a4* which join in midline; apodeme *a2* free posteriorly; lateral margin of apodeme *a2* forms heavily sclerotized processes at base trochanters I-II; *st2* joins *a4* and united *a5*; *st3* not quite touching *st4*. Disc *di1* lies on *a2*, equal in size to *di2* and smaller than *di3*. Suctorial plate with crenulated margins. Plate discs *pd1* larger than *H. julorum*. *Dorsum*. — Smooth except for a wide band of faint transverse striations at the anterior margin of the hysterosoma. Propodosoma with a thin, transparent membrane extending anteriorly, apparently from beneath. All setae long, fine, and flexible; *dm1*, *dm2*, *do1*, and *do5* over one-half the length of the hysterosoma, others slightly variable in length. *Legs*. — Legs I-II shorter than *H. julorum* especially the tarsi; seta *ta16* leg I lancet-shaped with distal end finely tapered; *ta16* leg II lancet-shaped; other leg setae generally larger than *H. julorum*, except femoral setae legs I-II. Seta *ta3* leg I nearly equal length of tarsus II.

*Remarks*. — Only the deutonymph was described by Oudemans and Womersley. Outstanding features are: unusual membranous anterior extension, arrangement of apodemata, large central discs on the suctorial plate, the wide band of transverse striations on the anterior hysterosoma, and the long fine dorsal setae. Although the dorsal setae are flexible they are easily broken and sometimes appear as stubs, or may be entirely missing. The combination of adult characteristics most useful in identifying this species is for the female: non-serrated chelicerae, long pedipalpal seta *pp1*, shape of *r2*, position of *vm3* with respect to *r2*, long dorsal setae, the position and structure of the bursa copulatrix, generally heavy leg setae and especially the unique barbed setae *ta5* of legs III-IV. For the male: gnathosoma as in female, arrangement of ventral setae, heavy leg setae legs I-II, dorsal sculpturing, and long fine dorsal setae.

*Collections*. — Collected by Prof. Ritzema Bos on *Oniscus asellus*

L., Leiden, South Holland, Netherlands, 1902; by K. J. W. Kempers on *Oxythyrea funesta*, Meerssen Limburg, Netherlands, 1903; on passalid, Amani, Dutch East Africa, 1911; on a small beetle, Crawley, Western Australia, Sept. 1940; by R. D. Hughes near compost pile, near Ellerson, Va., fall 1954; in duck pen near Ellerson, Va., Aug., 1955, and in damp woods, near Ellerson, Va., Oct. 1955.

*Types.* — Holotype in Natural History Museum in Hamburg. Plesiotypes (supplied by present authors) in U. S. National Museum, Washington, D. C. Plesiotypes in authors' collection.

*Histiostoma piloseta* sp. nov.

(Plates 39, 40)

*Female.* — (Plate 40). Length 0.350 mm.; width 0.220 mm. *Venter.* — Granular on gnathosomal base and on coxae at base of trochanters. Chelicera non-serrated, but bearing two "raking" processes; cheliceral flagellum nearly equal to *pp1*, but finer; pedipalpal seta *pp1* approximately equal to *dp2*; *pp2* short and fine. Ringlike structures extremely small, approximately one-third size of, but comparable in position to *H. julorum*. Setae generally somewhat shorter than *H. julorum*, all nearly equal, except *pp3* which is one-third length *vm1*. Seta *vm1* more mesiad in position than in *H. julorum*. Seta *do7* is ventral in position. *Dorsum.* — Rostrum granular and faintly sculptured; hysterosoma distinctly granular. Seta *dp1* similar to *H. julorum*; *dp2* slightly longer; all other dorsal setae slightly variable in size and distinctly pilose, except *do7*. Except for *dp1* all dorsal setae are borne on distinctly raised bosses. Setae *dp3*, *dp4*, *do1*, and excretory pore are borne on single bosses. The bursa copulatrix is elevated with a posterior opening, is heavily granular and lies on a line connecting setae *do1*. The pit-like structure *dpi3* not observed. *Legs.* — Legs longer and heavier in comparison with body size than *H. julorum*; leg setae generally larger, especially *ta1*, *ta2*, *ti2*, *g3*, and *g4* of leg I; *ta1*, *ti2* and *g3* of leg II; *ti1* and *ta4* of legs III-IV. Seta *t* of legs I-III, and *f* of leg IV shorter than in *H. julorum*; claws generally heavier.

*Male.* — (Plate 40). Length 0.215 mm.; width 0.120 mm. *Venter.* — Venter faintly granular. Gnathosoma as in female. Sternum extended more posteriorly and combined apodemata *a4-a5* extended more mesially than in *H. julorum*. Ringlike structures small, one-third size of *H. julorum*; *r2* round or ellipsoid, lateral to the external genitalia, and contiguous with *a8*. Distinct genital and anal plate. Setae variable in length. In comparison with setae of *H. julorum* seta *vp1* shorter and closer to midline; *vm1* longer and antero-mesiad of *r1*; *vm3* longer, antero-mesiad of *r2*; *vo1* longer, borne on the anal plate, opposite the mid-region of

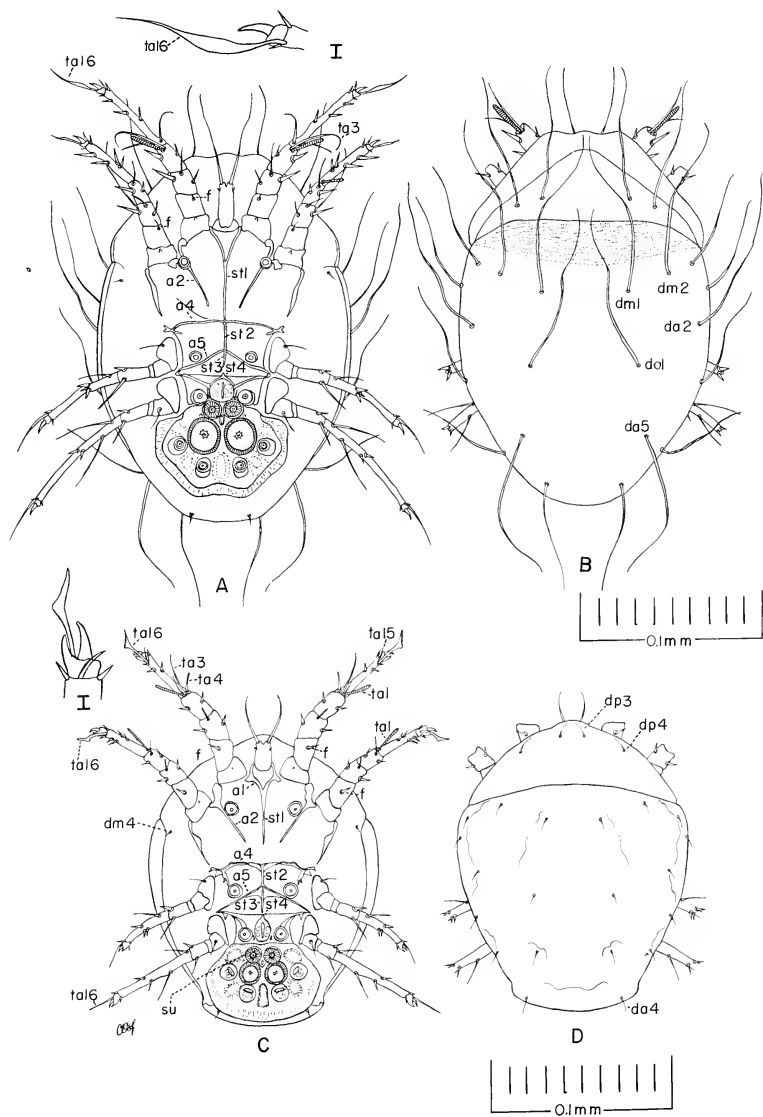


Plate 39 — Upper, *Histiostoma phyllophorus* deutonymph. A — venter. B — dorsum. Lower, *Histiostoma piloseta* deutonymph. C — venter. D — dorsum.

the anus; *vo2* shorter, borne on posterior margin of anal plate; *vo3* less than one-half as long. Penial seta directed anteriorly. *Dorsum*. — Dorsum faintly granular; rostrum and propodosoma more heavily granular than hysterosoma. Setae hairlike, somewhat variable in length; metapodosomal setae equal to *dp3*; opisthosomal setae slightly longer except *do2* equal metapodosomal setae; *do1* longest of dorsal setae; only the pit-like structure *dpi2* was observed. Unlike the female, the male is without bosses, except one bearing *dp2*. *Legs*. — Legs more slender than *H. julorum*; tarsus I longer; setae similar except: leg I, mid-tarsal setae more widely spread and generally smaller, *ta1* and *ta2* slightly larger, *ti2* three times as long, *g3* and *g4* longer, *g1* larger; leg II *ta6* and *ta7* smaller, *ta1* nearly four times as long, *ti2* and *ti3* longer; setae *t* legs I-III, and *f* leg IV shorter. Claws as in the female.

*Deutonymph*. — (Plate 39). Length 0.160 mm.; width 0.127 mm. *Venter*. — Fused pedipalps equal tibia I; pedipalpal seta *pp1* twice length of fused pedipalps. Apodemata *a1* with lateral sclerotized processes contiguous with trochanters I; *st1* free; apodeme *a2* heavily sclerotized forming a "T"-shaped structure anteriorly which is contiguous with trochanters I-II, posterior end free; *a4* distinctly raised, undulating, and continuous in midline with *st2*; *a5* continuous in midline with *st2* and *st3*; posteriorly *st3* does not quite meet *st4*. Discs *di1*, *di2*, and *di3* equal and distinctly larger than in *H. julorum*, and somewhat smaller than *su*; sutorial plate nearly hexagonal. The posterior end of opisthosoma is broad and ventrally turned. *Dorsum*. — Smooth, except hysterosoma irregularly and inconstantly crenulated. Setae medium in length, slightly variable, and hairlike; *dp3* and *dp4* equal and near anterior margin of propodosoma; hysterosomal setae variable and slightly shorter than *dp3*, except for the sub-marginal *do4*. *Legs*. — All legs shorter than in *H. julorum* due primarily to shorter tarsi. In comparison with *H. julorum* the following setae differences are noted: *f* legs I-II heavier and blunter, *tail* and *ta3* longer, *ta16* larger spoon-shaped; leg II *ta1* longer, *ta16* spoon-shaped; legs III-IV most setae slightly larger, *ta16* slightly shorter. Claw base of all legs is slightly tapering.

*Remarks*. — The body shape, leg shape, and gnathosomal structure of the male and female are very similar. Marked sexual dimorphism exists with respect to presence or lack of pilose dorsal setae, dorsal bosses, granulation, and rostral sculpturing. The combination of adult characteristics most useful in identifying this species is as follows: non-serrated chelicera, pedipalpal seta of medium length, and small ringlike structures. In the female the usual pilose dorsal setae borne on bosses, heavily granular hysterosoma, and the position of the bursa copulatrix nearly in the center of the hysterosoma are distinctive. In the male the faintly granular dorsum and venter; relatively short hairlike dorsal setae, presence of anal and genital plate, position of *vm1* and *vm3*, and the ex-

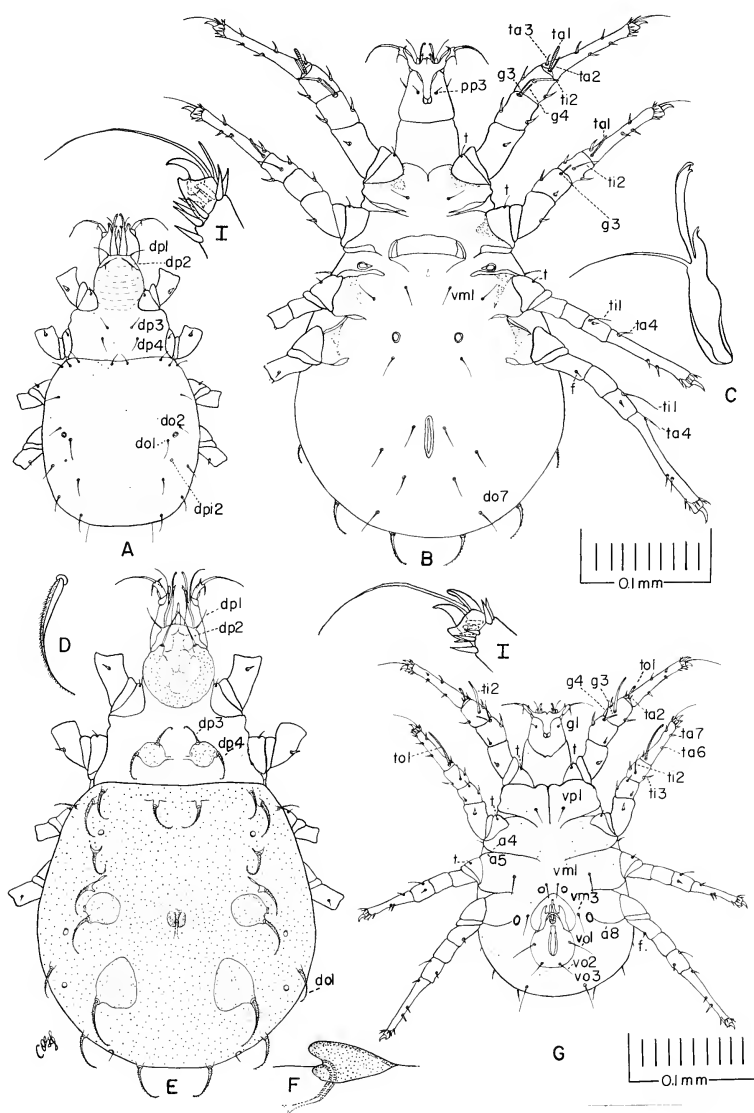


Plate 40 — *Histiostoma piloseta*. A — male, dorsum. B — female, venter. C — chelicera. D — dorsal pilose seta. E — female, dorsum. F — bursa copulatrix. G — male, venter.

ceptionally long seta *ti2* leg I and *tal* leg II are outstanding features. Characteristics useful in identifying the deutonymph are: entirely smooth dorsum, except for inconstantly crenulated hysterosoma, fused pedipalps and pedipalpal setae of medium length, heavy apodemata, large coxal I, III, and IV discs, relatively short legs, and the unusual tapering claw base.

*Collections.* — Collected by R. D. Hughes from compost near Ellerson, Va., Nov. 1954.

*Types.* — Holotype and paratypes in U. S. National Museum, Washington, D. C. Paratypes in authors' collection.

*Histiostoma polaki* (Oudemans), 1914

(Plate 41)

*Anoetus polaki* Oudemans, 1914; *Histiostoma polaki* (Oudemans), 1914 [Buitendijk, 1945].

*Female.* — No information.

*Male.* — No information.

*Deutonymph.* — (Plate 41). Length 0.153 mm.; width 0.111 mm. *Venter.* — Fused pedipalps equal to tibia I; pedipalpal seta *ppl* nearly equal to tarsus II. Apodemata *a1* short; sternum *st1* and apodeme *a2* continuous with *a4* which latter meet in midline; *st2* connected to *a4* and *a5* with faint rounded expansion in mid-region *st3* free posteriorly. Coxal discs *di1* lie on *a2* and are equal to *di2* and *di3*. *Dorsum.* — Smooth except for faint transverse striations on anterior margin of hysterosoma; setae minute, hairlike, and equal. Membranous expansions extend from antero-lateral margins of propodosoma. *Legs.* — Leg shape, setae size and setae arrangement similar to *H. julorum*.

*Remarks.* — The granular appearance of the dorsum is due to the fact that Oudemans' drawing was tinted. The features most useful in identifying this species are the arrangement of the apodemata as described above and the rounded expansion of *st2*. The complete complement of dorsal and leg setae are not shown in Oudemans' drawings.

*Collections.* — Twenty specimens on *Spriostreptus* sp. (Myriapoda), Dutch East Africa, collected by R. Polak, June 1912.

*Types.* — Holotype in Oudemans' collection.

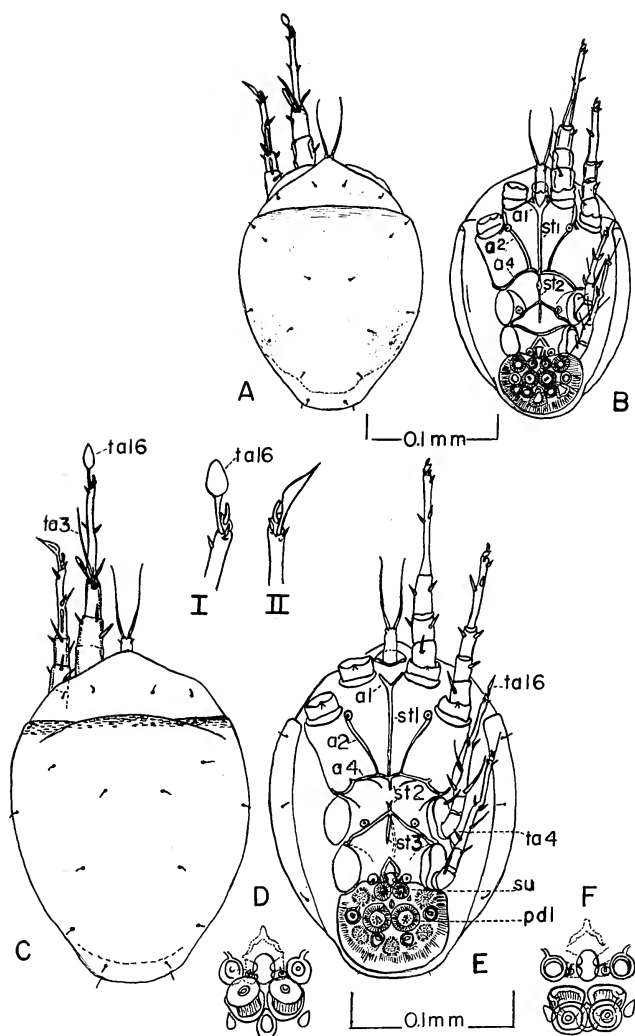


Plate 41 — Upper, *Histiotoma polaki* deutonymph. A — dorsum. B — venter. (Original unpublished drawing by A. C. Oudemans)  
 Lower, *Histiotoma polypori* deutonymph. C — dorsum. Middle, legs I and II. D and F — details of portions of the suckorial plate; D — suckers distended, F — suckers retracted. E — venter. (Original unpublished drawing by A. C. Oudemans)

*Histiostoma polypori* (Oudemans), 1914

(Plate 41)

*Anoetus polypori* Oudemans, 1914; *Histiostoma polypori* (Oudemans), 1914 [Buitendijk, 1945].

*Female*. — No information.

*Male*. — No information.

*Deutonymph*. — (Plate 41). Length 0.200 mm.; width 0.140 mm. *Venter*. — Fused pedipalps nearly equal to tibia I; pedipalpal seta *pp1* equal to tarsus II. Apodemata *a1* short, joining to form sternum *st1* which makes contact with *a4*; apodeme *a2* meets *a4* apodemata *a4* continuous in midline with *st2*; posterior portion of *st2* forms short "Y"-shaped process; *a5* joins in midline; *st2-st3* united with *a5*, with a membranous portion joining *st4*. Coxal discs *di1-di3* approximately one-half diameter of functional sucker *su*; central suctorial plate discs *pd1* approximately twice the diameter of *su*. Suctorial plate large. *Dorsum*. — Smooth except for anterior margin of hysterosoma which is faintly transversely striated; setae minute, hairlike and equal. Lateral margins of hysterosoma distinctly turned ventrally. *Legs*. — Leg shape, setae size and arrangement similar to *H. julorum*, except: leg I *ta3* equal to tarsus II, *ta16* spoon-shaped; *ta16* legs II-III lanceolate, *ta4* leg IV short, spine-like.

*Remarks*. — Features most useful in identifying the deutonymph of this species are: length of fused pedipalps and *pp1*, large suctorial plate, arrangement of apodemata, smooth dorsum, minute setae, length of *ta3* leg I, shape of *ta16* legs I-III.

*Collections*. — Collected by D. MacGillavry on *Polyporus* sp., Oosterbeek, July 1911; by A. C. Oudemans on *Eugamasus cornutus*, Amsterdam, September, 1900, and on *Forficula auricularia*, Arnhem, August 1900; by G. H. Vitzthum in Weimar, July 1912; by B. K. Behura on *Forficula auricularia*, Edinburgh, 1950.

*Types*. — Holotype in Oudemans' collection.

*Histiostoma prodectoris* (Vitzthum), 1920, new combination

(Plate 42)

*Anoetus prodectoris* Vitzthum, 1920.

*Female*. — No information.



*Male.* — No information.

*Deutonymph.* — (Plate 42). Length 0.156-0.160 mm.; width 0.095-0.100 mm. Shape nearly rectangular. *Venter.* — Fused pedipalps one-half length of tibia II; pedipalpal seta *pp1* nearly twice length of tibia I. Sternum *st1* free; apodeme *a2* free or faintly united with apodeme *a4*; apodemata *a4* joined in midline and continuous with sternum *st3*; *st3* and *st4* united with apodemata *a5*. Coxal disc *di1* lies on *a2*, and is slightly larger than *di2*; *di1* and *di2* smaller than *di3* which latter is equal to functional sucker *su*. *Dorsum.* — Smooth. Setae variable in length; *dp3* twice as long as *dp4*; *dm2* three times length of other hysterosomal setae except *do4*. *Legs.* — Shape and relative proportions of segments generally similar to *H. julorum*, except tarsus II is equal to tarsus I; legs I-II *ta16* tapering; *ta16* leg IV longer than in *H. julorum*; *ta3* leg I two-thirds length of tarsus I.

*Remarks.* — Features most useful in identifying this species are as follows: relatively short fused pedipalps, long *pp1*, long tarsus I-II, small coxa I-III discs, smooth dorsum with setae variable in length, *dp3* longer than *dp4*. The full complement of dorsal and leg setae not shown or observed by Vitzthum.

*Collections.* — On *Prodictor fruhstorjeri* Senna from Bua-Kraeng in South Celebes, and on *Ectocemus cinnamomeus* Herbst from Luzon, Philippines.

*Types.* — In Vitzthum's collection.

*Histiostoma prophthalmi* (Vitzthum), 1920, new combination  
(Plate 42)

*Anoetus prophthalmi* Vitzthum, 1920.

*Female.* — No information.

*Male.* — No information.

*Deutonymph.* — (Plate 42). Length 0.174 mm.; width 0.120 mm. Shape ellipsoid. *Venter.* — Fused pedipalps nearly equal length of tibia II; pedipalpal seta *pp1* one-half length of tarsus I; extends well beyond gnathosoma. Apodemata *a1* short, joining to form *st1* which ends free posteriorly; *a2* ends free; apodemata *a4* continuous in midline and united with *st2*; apodemata *a5* continuous in midline and united with *st2* and *st3*. Coxal discs *di1* lie on *a2*, equal in size to *di2*, less than one-half the size of the functional sucker *su*. *Dorsum.* — Smooth except faint striation at anterior margin of hysterosoma. *Legs.* — Shape generally sim-

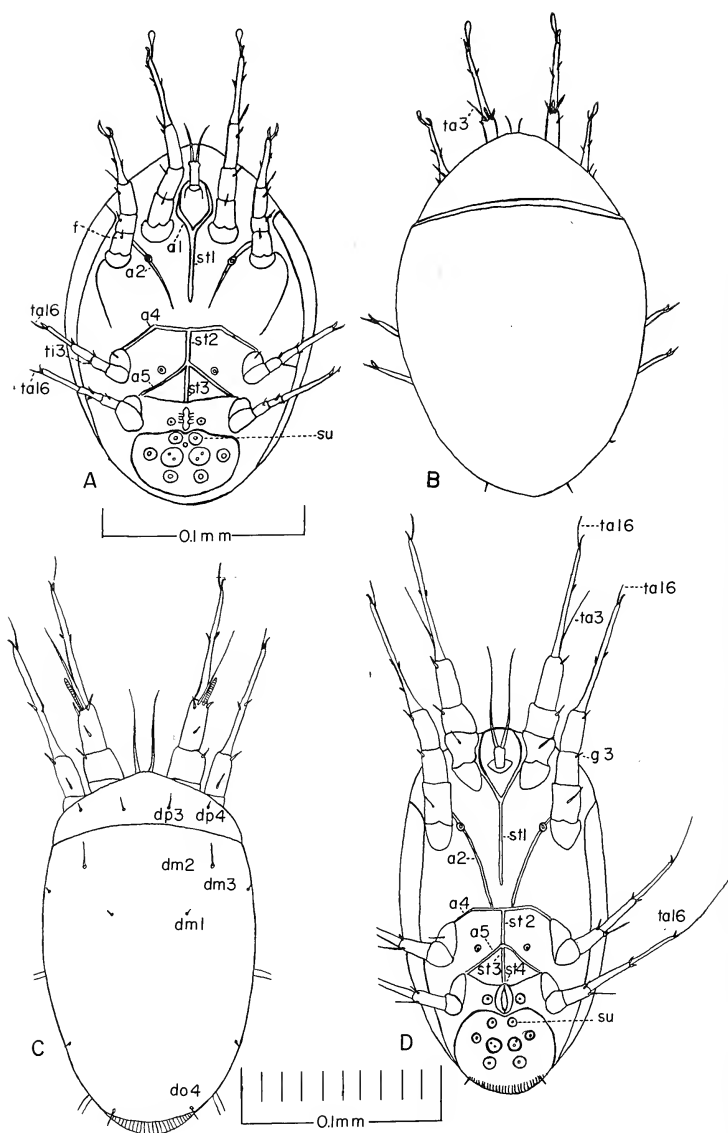


Plate 42 — Upper, *Histiostoma prophthalmi* deutonymph. A — venter. B — dorsum. (After Vitzthum) Lower, *Histiostoma prodectoris* deutonymph. C — venter. D — dorsum (After Vitzthum)

ilar to *H. julorum* except for the shorter tarsus I-II, and shorter and finer legs III-IV; setae differences as follows: leg I *ta3* shorter; leg II *f* one-third as long; leg III *ti3* shorter, *ta16* twice as long as claw; leg IV without long setae, *ta16* equal to claw.

*Remarks.* — Features most useful in identifying this species are as follows: arrangement of apodemata, coxal discs *dil* lie on *a2*, small, equal to size of *di2*, tarsi I-II short, legs III-IV short and fine; propodosoma extending distinctly beyond short fused pedipalps, *pp1* one-half length of tarsus I. Dorsal setae and leg setae not observed or drawn by Vitzthum.

*Collections.* — Collected by R. Kleine on *Prophthalmus potens* Lacordaire, in Assam, India.

*Types.* — Holotype in Vitzthum's collection.

*Histiostoma protuberans* sp. nov.

(Plates 43, 44)

*Female.* — (Plate 43). Length 0.400 mm.; width 0.235 mm. *Venter.* — Chelicera finely serrated bearing approximately 10 extremely fine teeth distally, 14 slightly larger proximal teeth borne on expanded region; median member of chelicera short, blunt, and with four rounded toothlike structures distally; cheliceral flagellum shorter and heavier than *H. julorum*. Pedipalpal seta *pp1* anteriorly directed, shorter than most dorsal setae, approximately equal to *dm1*, three times length of *pp2*; distal portion of pedipalps with mesially directed projection. Ventral setae similar in position but generally longer than in *H. julorum* except *vm1* nearly equal, *vm3* mesiad of *r2*, *vo3* shorter. Ringlike structure *r2* small, nearly round, and more heavily sclerotized than in *H. julorum*. *Dorsum.* — Granular and sculptured; rostrum heavily sculptured, hysterosoma very faintly sculptured; lateral and posterior regions of the hysterosoma with distinct elevations which appear to bear numerous smaller bosses, giving a wart-like appearance. By comparison with *H. julorum* the dorsal setae differ as follows: *dp1* one-third as long, *dp2* slightly shorter, *dp3* longer, *dp4* shorter; all hysterosomal setae shorter and finer. Bursa copulatrix slightly posterior to a line between setae *do5*, elongated, and originating from the bottom of a cup-like structure. *Legs.* — Leg shape and setae arrangement similar to *H. julorum* except: leg I *ti2* longer, leg II *g3* longer, *ti2* almost three times as long. Leg III *t* twice as long, *ta9* over twice length of claw; leg IV *f* twice as long, *ta9* over twice length of claw.

*Male.* — (Plate 43). Length 0.324 mm.; width 0.190 mm. *Venter.* — Gnathosoma as in female. Setae similar in position, and considerably long-

er than in *H. julorum* except; *vm3* antero-mesial of posterior ringlike structures *r2*, *vo2* mesial of *r2*, *vo3* approximately equal in length. Ringlike structures small, nearly round; *r2* on a line with the anus, and surrounded by a faint chitinous structure which is pointed anteriorly. *Dorsum*. — Granular and sculptured, rostrum more heavily sculptured than propodosoma and hysterosoma; hysterosoma with unique elevations as in female. Setae generally somewhat longer than in female. A distinct posteriorly directed elevation or pseudo-bursa, is seen in the position of the true bursa copulatrix of the female. The male of the "bursoid variety" of *H. julorum* also has a pseudo-bursa. Dorsal pit-like structure *dpi3* could not be observed. *Legs*. — All legs heavier than in *H. julorum*, especially legs I-II which are exceptionally gross. Setae similar in position except mid-tarsal setae of leg I more widely separated. Setae differences worthy of note are as follows: leg I *f* and *ta7* heavier; leg II *f*, *ta6* and *ta7* heavier; leg III *t* three times as long, *ta9* over three times length of claw; leg IV *f* twice as long, *ta9* over three times length of claw. All claws heavier than in most anoetids.

*Deutonymph*. — (Plate 44). Length 0.188 mm.; width 0.139 mm. *Venter*. — Fused pedipalps equal in length to genu I, expanded in mid-region, and not extending beyond base of gnathosoma; seta *pp1* equal to tarsus I. Sternum *st1* free posteriorly; apodeme *a2* faintly united with *a4*; the more chitinous portions of *a4* not united; membranous portions *a4* appear to be united; *st2* short, united with *a5*, and not connected with *a4* anteriorly; *a5* united to *st2-st3* in midline; *st3* and *st4* almost touching. Coxal discs nearly equal in size, somewhat smaller than suctional plate discs *pd2* and *pd3*; suctional plate large. *Dorsum*. — Hysterosoma completely and coarsely granular; propodosoma sparsely granular with distinct line of transverse sculpturing. Setae hairlike, one-half the length of tibia II, and equal. *Legs*. — All legs shorter than *H. julorum*; tarsi I-II relatively short. Setae differ from *H. julorum* as follows: leg I *f* longer, *g1*, *g2* finer, *g3* shorter, *ta4* twice as long, mid-tarsal setae more closely grouped; leg II *g1*, *g2* finer, *ta16* nearly spoon-shaped; leg III *t* longer; leg IV *f* shorter; all claws smaller.

*Remarks*. — Features most useful in identifying this species are as follows: for the adult, the unusual chelicera, anteriorly directed pedipalpal seta *pp1*, comparatively long ventral setae, position of ventral discs and seta *vm3*, unique dorsal elevations, dorsal sculpturing, and terminal tarsal seta *ta9* legs III-IV over twice length of claw; for the female the unusual bursa copulatrix with surrounding cup-like structure, and for the male the unusual "pseudo-bursa"; for the deutonymph, short fused pedipalps expanded in mid-region, pedipalpal setae longer than tarsus II, arrangement of apodemata, and large suctional plate, the completely granular dorsal hysterosoma and short, hairlike setae of equal length, compara-

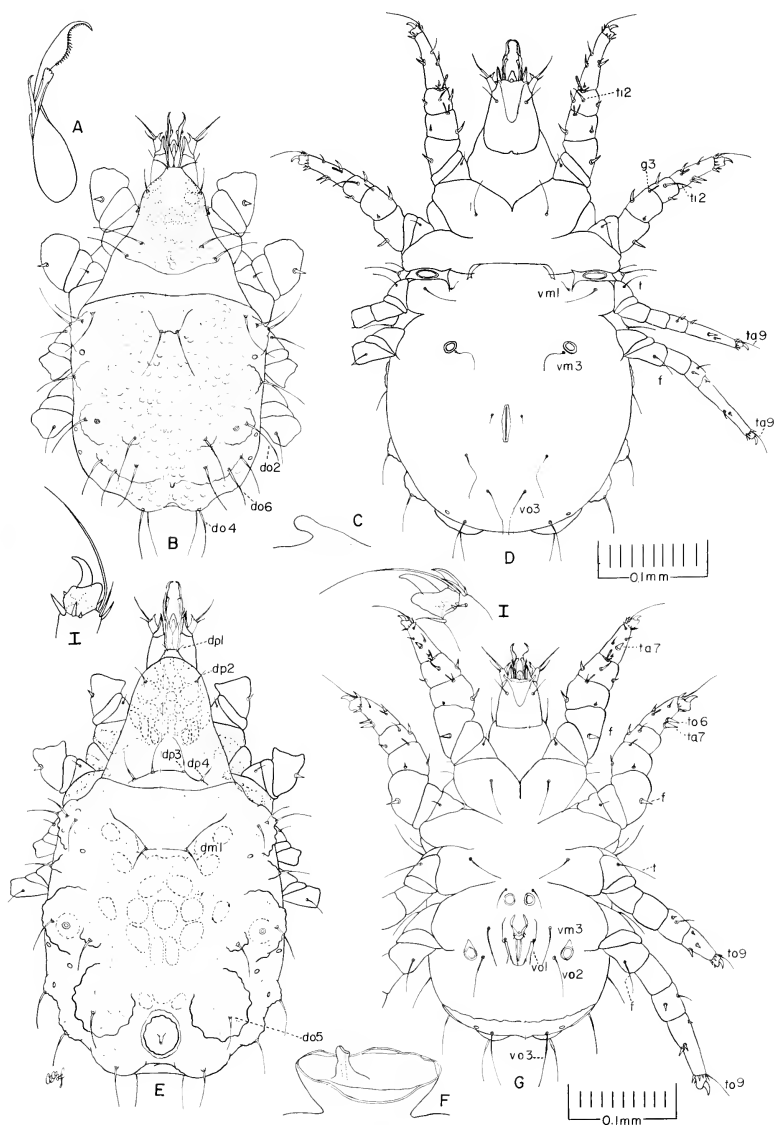


Plate 43 — *Histiostoma protuberans* sp. nov. A — chelicera. B — male, dorsum. C — male, pseudo-bursa copulatrix. D — female, venter. E — female, dorsum. F — bursa copulatrix. G — male venter.

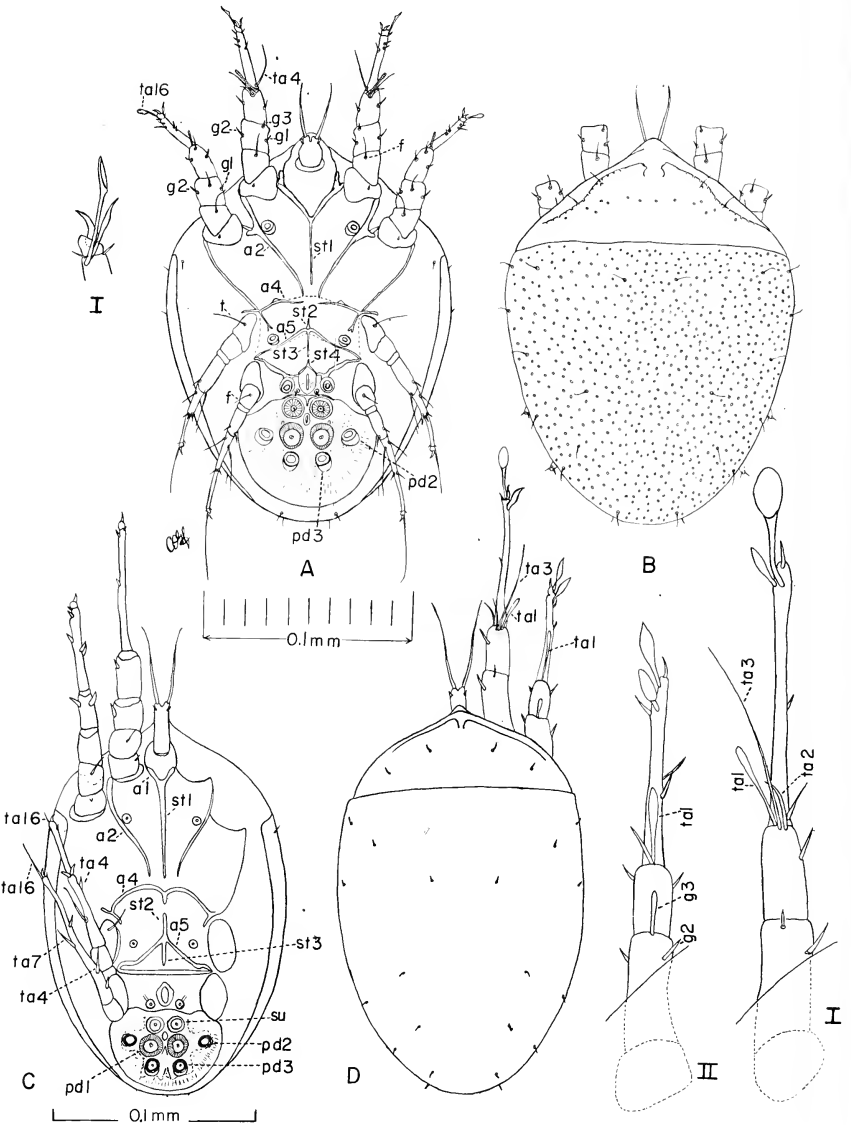


Plate 44 — Upper, *Histiostrongylus protuberans* sp. nov. deutonymph. A — ventral. B — dorsum. Lower, *Histiostrongylus sapromyzarium* deutonymph. C — ventral. D — dorsum. Right, legs I and II. (After Oudemans)

tively short legs, relatively short tarsi I-II, *ta4* leg I extremely long. This species is arrhenotokous.

*Collections.* — Collected by C. O. Goode near University of Richmond, 8 miles west of Richmond, Va., October, 1950; by R. D. Hughes at Norris Dam, Tenn., July 1951 and in Chickahominy Swamp, near Ellerson, Va., June, 1953.

*Types.* — Holotype and paratypes in U. S. National Museum, Washington, D. C. Paratypes in authors' collection.

*Histiostoma pyriforme* Michael, 1901

(Plate 45)

*Female.* — (Plate 45). Length 0.300 mm.; width 0.130 mm. Pear-shaped. *Venter.* — Chelicera bearing approximately 18 equal teeth; cheliceral flagellum extending nearly to end of chelicera. Pedipalpal seta *pp1* three times length of *pp2*; *pp2* equal to genu I. Ringlike structures nearly circular. *Dorsum.* — Smooth, except for faintly sculptured rostrum. Propodosomal seta *dp4* one-third longer than *dp3*; hysterosomal setae twice as long as *dp4*, except *dm4*. *Legs.* — Legs II-IV longer and setae all legs generally larger than *H. julorum*. Terminal tarsal setae *ta9* legs III-IV longer than tarsi III-IV. Claws long and nearly straight.

*Male.* — (Plate 45). Length 0.250 mm.; width 0.120 mm. Shape oblong. *Venter.* — Gnathosoma as in female. The ventral setae shown are spine-like, not long and tapering as in *H. julorum*. Ringlike structures nearly circular; *r2* widely separated, opposite genitalia. *Dorsum.* — No figure; presumed to be similar to female. *Legs.* — Legs generally heavier than female; setae similar including the extremely long terminal tarsal setae *ta9* legs III-IV. Leg I with claw-shaped terminal tarsal seta typical of this family, described but not shown in Michael's figure. (cf. Plate 5 — seta *ta15*). Claws long and nearly straight.

*Deutonymph.* — No information.

*Remarks.* — Features most useful in identifying this species are the serrated chelicera, long pedipalpal seta *pp1*, and the extremely long terminal tarsal setae on all legs. Michael found that most of the specimens were covered on the dorsal surface with living Vorticellidae. This probably accounts for his failure to observe many dorsal and leg setae.

*Collections.* — In exuded sap and decaying debris on beech trees, *Fagus sylvatica*. Collected by A. D. Michael, probably in England, 1901.

*Types.* — No record.

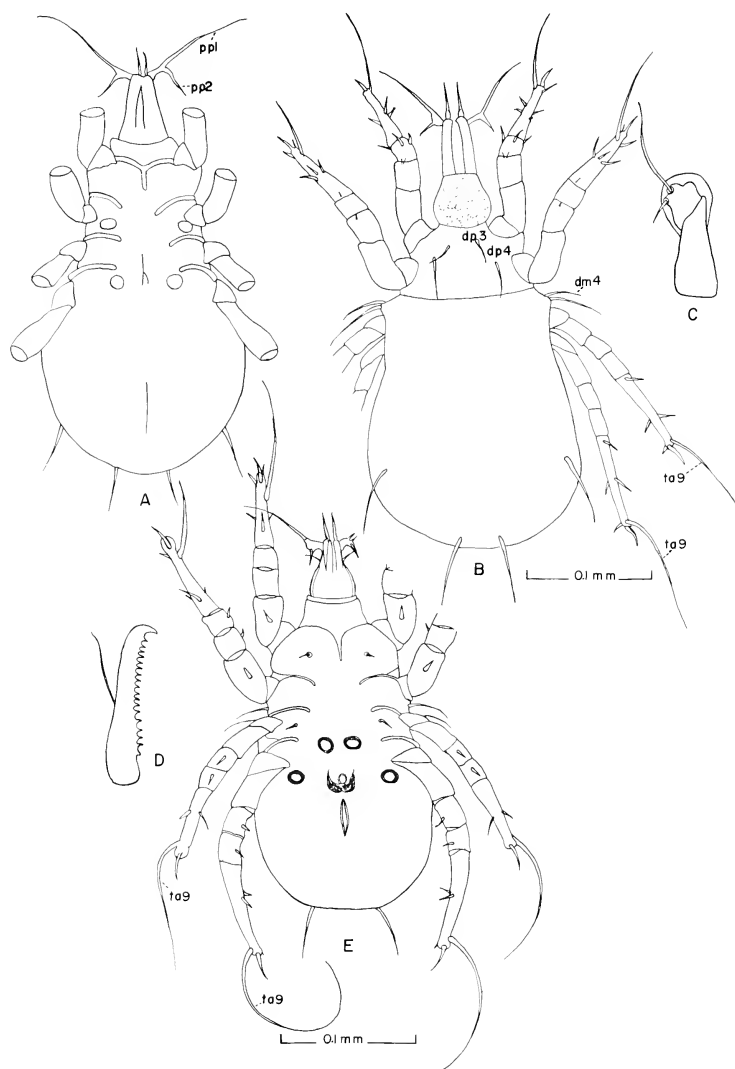


Plate 45 — *Histiostoma pyriforme*. A — female, venter. B — female, dorsum. C — pedipalp. D — chelicera. E — male, venter. (After Michael)



*Histiostoma sapromyzarum* (Dufour), 1839

(Plate 44)

*Hypopus sapromyzarum* Dufour, 1839; *Anoetus sapromyzarum* (Dufour), 1839 [Oudemans, 1914b]; *Histiostoma sapromyzarum* (Dufour), 1839 [Buitendijk, 1945].

*Female*. — No information.

*Male*. — No information.

*Deutonymph*. — (Plate 44). Length 0.187 mm.; width 0.120 mm. *Venter*. — Fused pedipalps slightly longer than tibia I; pedipalpal seta *pp1* nearly one-third longer than fused pedipalps, shorter than tarsus II. Apodemata *a1* short, fusing to form *st1* which is free posteriorly; apodeme *a2* slightly "S"-shaped, ends free; apodemata *a4* slightly arched on each side united in midline with short anterior portion of *st2*; anterior and posterior portions of *st2* separated; *a5* united in midline with *st2* and *st3*. Coxal discs smaller than suctorial plate discs or suckers; functional sucker *su* equal to *pd2* and *pd3*, and smaller than *pd1*. *Dorsum*. — Smooth except for single transverse line of sculpturing at anterior margin of propodosoma. Setae minute, hairlike, and equal. *Legs*. — Legs generally similar in size and shape to *H. fulorum*, setae differences as follows: leg I *ta1* longer, *ta3* much longer; leg II *ta1* longer; leg III *ta4* shorter and more spine-like, *ta16* less than twice length of claw; leg IV *ta4*, *ta7*, and *ta16* shorter.

*Remarks*. — Features most useful in identifying this species are as follows: shape of fused pedipalps, length of pedipalpal setae, arrangement of apodemata, size of coxal discs, smooth dorsum except for anterior line of sculpturing on propodosoma, minute and equal dorsal setae, shape of *ta15* and *ta16* legs I-II, long *ta3* leg I, long *ta1* leg II and relatively short *ta16* leg III. One dorsal seta and many leg setae are not shown in Oudemans' drawings. Oudemans in 1924 stated that *Hypopus filicum* Dujardin, 1849 was a synonym of this species. In 1937 he placed *Hypopus filicum* in the genus *Myianoetus*.

*Collections*. — Collected by Dufour in *Sapromyzae blepharipteroides*, 1839; in Netherlands, Italy, and France, and on rotting hyacinth bulb, San Remo, Italy, Oudemans 1914; on *Dryocetes autographus* Ratz, from wood-farm on the Thaya, Neiderosterreich, Vitzthum, 1923; by Dr. Stadler in the nest of the bank swallow *Clivicola riparia*, at Lohram-Main, 1924, on *Schizotrachelus bakeri* Klein, from Philippines, on *Brenthus* from Bolivia and on *Phoeborus scaber* Erichson, from Brazil, Vitzthum, 1926.

*Types*. — Holotype in Oudemans' collection.

*Histiostoma sextoni* sp. nov.

(Plates 46, 47)

*Female*. — (Plate 46). Length 0.440 mm.; width 0.255 mm. Pear-shaped. *Venter*. — Chelicera finely serrated bearing approximately 18 equal teeth; median cheliceral process forked; lateral process short, equal to *pp2*, not flagella-like as in most anoetids. Pedipalpal seta *pp1* short, anteriorly directed, three times length of *pp2*. Setae similar in arrangement, generally slightly shorter than *H. julorum* except *vo1* slightly longer, and *vo2* equal; *do7* ventral in position. Ringlike structure *r2* elongated; *vm3* posterior to *r2*. *Dorsum*. — Dorsum smooth except for sculptured rostrum. Setae considerably longer than in *H. julorum*, except *dpl* which is equal. Bursa copulatrix on a line with *do5*, raised, granular, and opening posteriorly. *Legs*. — Similar in size, shape, and setae arrangement to *H. julorum*, with minute differences in setae size. Terminal tarsal setae *ta9* legs I-IV nearly equal and longer than claw. All claws larger, and less curved than *H. julorum*.

*Male*. — (Plate 46). Length 0.300 mm.; width 0.140 mm. Shape nearly rectangular. *Venter*. — Entire gnathosoma smaller than in *H. julorum*, similar to female except smaller. Setae slightly longer than *H. julorum*, except *vm1* and *vo2* equal. Position of setae similar to *H. julorum* except *vm3* posterior-mesial to ringlike structure *r2*, and *vo1*, *vo2* more posterior. Anterior ringlike structure *r1* round or oval, *r2* elongated, widely separated, and on a line with external genitalia. *Dorsum*. — Smooth except for sculptured rostrum. All setae considerably longer than *H. julorum*, except *dpl* slightly longer. *Legs*. — Leg shape, size and setae arrangement similar to *H. julorum*, except terminal tarsal setae *ta9* legs III-IV longer than claw, *t* and *ti2* legs I-II longer, and claws longer and less curved.

*Deutonymph*. — (Plate 47). Length 0.158 mm.; width 0.122. *Venter*. — Fused pedipalps one-half length of tarsus I; pedipalpal seta *pp1* equal to fused pedipalps. Sternum *st1* sometimes appears to be connected by faint membranous portion to *a4*; apodeme *a2* faintly continuous with *a4*; apodemata *a4* sometimes appear to be joined in midline; *st2* free anteriorly, posteriorly joined to united apodemata *a5*; *st3* thin, contiguous with *st4*. Coxal discs somewhat smaller than suctorial plate discs *pd2* and *pd3*. *Dorsum*. — Smooth except for three transverse lines of sculpturing on the anterior propodosoma, and transverse striations on the anterior margin of the hysterosoma. Most dorsal setae equal or nearly equal in length to genu I; *do3*, *do4*, and *do6* approximately one-half as long. *Legs*. — Tarsi I-II equal to combined length of femur, genu, and tibia. Setae generally smaller than *H. julorum*, except: *tal-ta3* leg I, and *tal* leg II which are longer. Seta *ta3* leg I equal to tarsus II. Seta *ta16* legs I-II lancet-shaped.

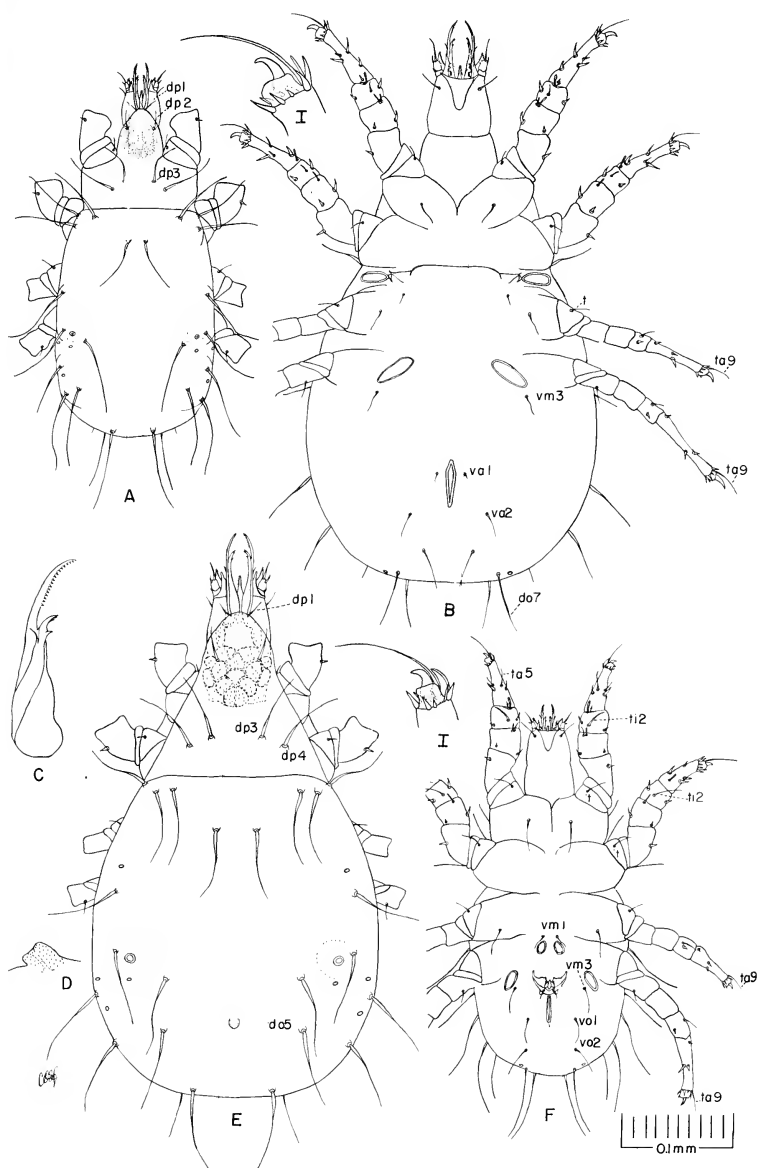


Plate 46 — *Histiostoma sextoni* sp. nov. A — male, dorsum. B — female venter. C — chelicera. D — bursa copulatrix. E — female, dorsum. F — male, venter.

*Remarks.* — The combination of adult characteristics most useful in identifying this species is as follows: finely serrated chelicera, lateral cheliceral process not flagellum-like, short anteriorly directed pedipalpal seta *pp1*, elongated ringlike structures *r2*, smooth dorsum except for rostrum, long terminal tarsal seta *ta9* legs III-IV, and unusually long dorsal setae. For the female *vm3* posterior to *r2*, and bursa copulatrix raised and directed posteriorly; for the male *vm3* mesiad and posteriad of *r2*. Features most useful in identifying the deutonymph are as follows: fused pedipalps and pedipalpal setae equal in length, arrangement of apodemata, size of coxal discs, three lines of sculpturing on the dorsal propodosoma, transverse striations on the dorsal anterior hysterostoma, most dorsal setae equal or nearly equal in length to genu I, seta *ta3* leg I equal to length of tarsus II and *ta16* legs I-II lancet-shaped. This species is named in honor of Roy L. Sexton.

*Collections.* — Collected by R. D. Hughes in Chickahominy Swamp, near Ellerson, Va., October, 1951 and August, 1953, and in duck pen near Ellerson, Va., August, 1955.

*Types.* — Holotype and paratypes in U. S. National Museum, Washington, D. C. Paratypes in authors' collection.

*Histiostoma spinitarsus* (Oudemans), 1901

(Plate 48)

*Hypopus spinitarsus* Oudemans, 1901; *Anoetus spinitarsus* Oudemans, 1917; *Histiostoma spinitarsus* (Oudemans), 1901 [Buitendijk, 1945]

*Female.* — No information.

*Male.* — No information.

*Deutonymph.* — (Plate 48). Length 0.143 mm.; width 0.099 mm. *Venter.* — Fused pedipalps equal to tibia I; pedipalpal seta *pp1* equal to tarsus II. Apodemata *a1* heavily sclerotized at base of trochanters I, united to form sternum *st1* which continues posteriorly and is joined with *a4* by a fainter portion; apodeme *a2* heavily sclerotized at base of trochanters I-II and joins with *a4* posteriorly; apodemata *a4* join in midline; sternum *st2* continuous with *a4* and *a5*; *st3* free posteriorly. Coxal disc *di1* lies on the heavily sclerotized anterior extension of *a2*, slightly smaller than *di2*; *di3* larger than *di2*. Suctorial plate large, circular, otherwise similar to *H. julorum*. *Dorsum.* — Propodosoma sparsely pitted; hysterostoma heavily pitted, transversely striated anteriorly. Setae *dml* and *dol* lancet-shaped equal to tarsus II; other setae fine and variable in length. *Legs.* — Leg size and arrangement similar to *H. julorum*, ex-

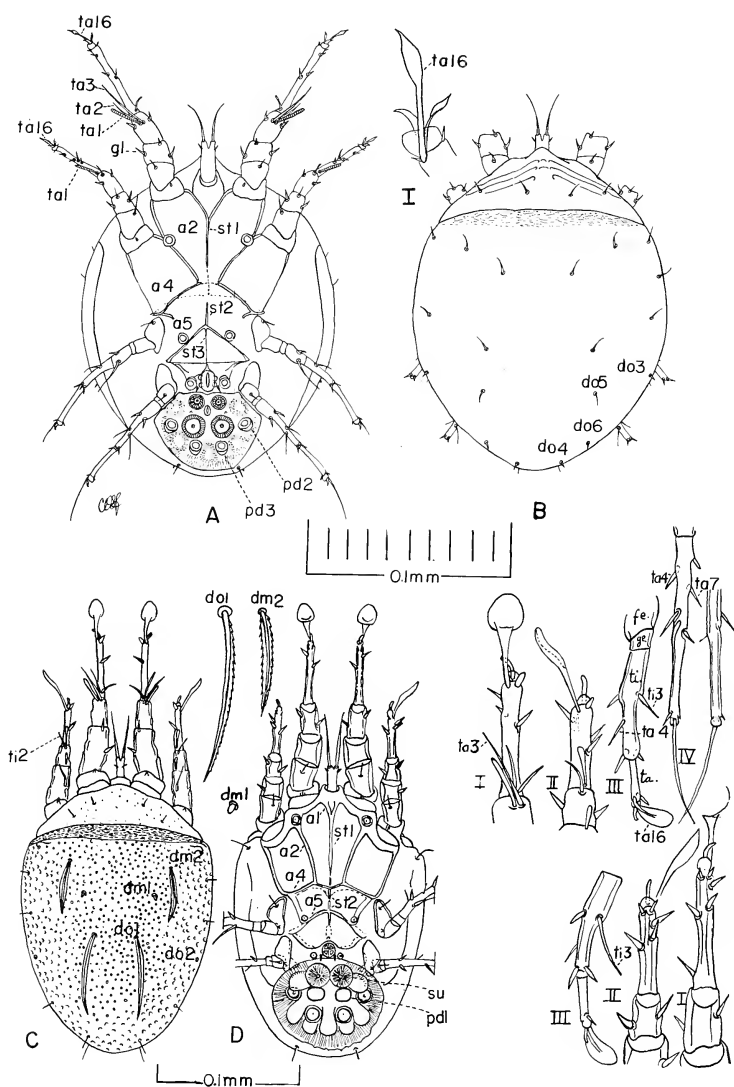


Plate 47 — Upper, *Histiostoma sextoni* sp. nov. deutonymph. A — venter. B — dorsum. Lower, *Histiostoma tienhoveni* deutonymph. C — dorsum. Middle, seta *do1*, *dm2*, and *dm1*. D — venter. Right, legs I-IV (Original unpublished drawing by A. C. Oudemans)

cept *g3* leg I longer, *ti2* leg II longer, no long setae on leg IV. All legs with claws.

*Remarks.* — Features most useful in identifying this species are: the heavily sclerotized ventral areas adjacent to trochanters I-II, the heavily sclerotized area surrounding *di2*, unusual coxal discs which Oudemans describes as short club-shaped organs, arrangement of apodemata, large and nearly round suctorial plate, pitted soma, hysterosoma transversely striated anteriorly, and two pairs of long lancet-shaped setae on dorsum. Oudemans stated that the two specimens examined by him were defective. This may account for the two missing dorsal setae and for the absence of *ta16* leg IV. Oudemans in about 1910 examined 5 specimens similar to this species collected by Berlese in rotting wood in Florence. Because of the similarity of *H. spinitarsus* he called them *Hypopus tarsispinus*. Because of the inadequate description of these specimens, *Hypopus tarsispinus* is considered by the present authors to be a *nomen dubia*. According to Oudemans this form differs from *H. spinitarsus* as follows: longer fused pedipalps, legs slenderer, setae generally longer.

*Collections.* — Collected by H. J. Veth on *Phanaeus* sp. (Coprinae), South America, February, 1903.

*Types.* — In Oudemans' collection.

*Histiostoma tienhoveni* (Oudemans), 1926

(Plate 47)

*Anoetus tienhoveni* Oudemans, 1926; *Histiostoma tienhoveni* (Oudemans), 1926 [Buitendijk, 1945].

*Female.* — No information.

*Male.* — No information.

*Deutonymph.* — (Plate 47). Length 0.187 mm.; width 0.127 mm. *Venter.* — Fused pedipalps equal length of tibia II; pedipalpal seta *pp1* equal length of tarsus II. Gnathosomal base surrounded by heavily sclerotized apodemata *a1*, which join in midline to form sternum *st1*; *st1* faintly joined to *a4*; heavily sclerotized portion of apodeme *a2* adjacent to trochanters I-II anteriorly; posteriorly *a2* united with *a4*; *a4* united in midline with *st2*; *a5* united and joined with *st2* and *st3*. Coxal disc *di1* lies on the heavily sclerotized anterior end of *a2*, and is larger than *di2-di3*. Suctorial plate almost circular; functional suckers *su* larger than in *H. julorum*, central discs *pd1* smaller. *Dorsum.* — Gnathosomal base extended anteriorly beyond propodosoma; propodosoma finely pitted;

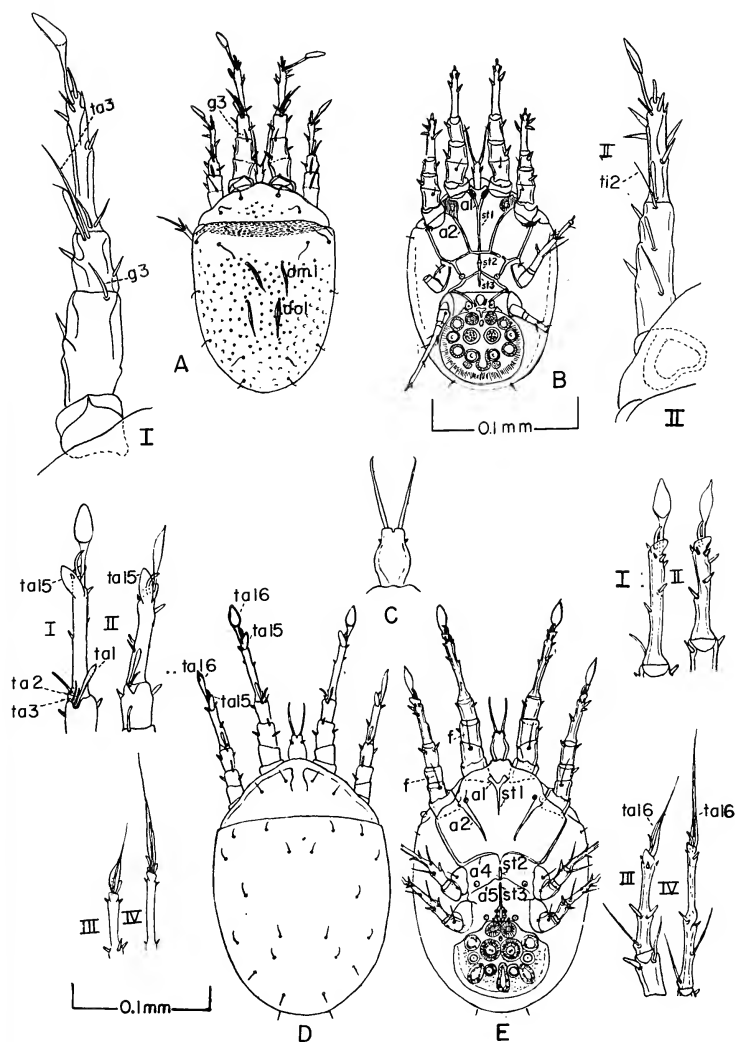


Plate 48 — Upper, *Histiostoma spinitarsus* deutonymph. Left, leg I. A — dorsum. B — venter. Right, leg II. (Original unpublished drawing by A. C. Oudemans) Lower, *Histiostoma toxopei* deutonymph. Left, legs I-IV, dorsal view. C — fused pedipalps. D — dorsum. E — venter. Right, legs I-IV, ventral view. (After Oudemans)

hysterosoma heavily pitted, with anterior margin transversely striated. All setae relatively short, hairlike, except *dm1* which is short and peg-like; *dm2* lancet-shaped, longer than tarsus II, with definite midrib and serrated edges; *do1* lancet-shaped, longer than tarsus I, with one margin serrated; and *do2* small, probably peg-like. *Legs*. — Tarsi I-II shorter than combined length of trochanter, genu, and tibia; otherwise leg size, shape, and arrangement similar to *H. julorum*, except: *ti2* leg II longer; leg III *ta4* shorter, *ta16* unstalked, membranous, rounded distally; leg IV *ta4-ta7* shorter; terminal tarsal seta, which probably represents a modified claw, long and tapering.

*Remarks*. — Features most useful in identifying this species are heavy anterior apodemata, *dil* on sclerotized anterior portion of *a2* and larger than other coxal discs; arrangement of apodemata, nearly circular suctorial plate, and size of functional suckers; dorsum pitted, hysterosoma with transversely striated anterior margin, serrated lancet-shaped hysterosomal setae; leg III *ta16* membranous, leg IV terminal tarsal seta long and tapering. It is possible that the unusual peg-like *dm1* actually represents a broken seta. The details of the central suctorial plate disc *pd1* are not shown in Oudemans' figure. It probably is larger than represented.

*Collections*. — In nest of *Talpa europaea*, Naardermeer, September, 1926.

*Types*. — One example in Museum Natura Artis Magistra, Amsterdam.

*Histiostoma toxopei* (Oudemans), 1927

(Plate 48)

*Anoetus toxopei* Oudemans, 1927; *Histiostoma toxopei* (Oudemans), 1927 [Buitendijk, 1945].

*Female*. — No information.

*Male*. — No information.

*Deutonymph*. — (Plate 48). Length 0.184 mm.; width 0.126 mm. Shape ellipsoid. *Venter*. — Fused pedipalps equal to tibia II, expanded in middle; pedipalpal setae equal fused pedipalps. Apodemata *a1* joining to form short sternum *st1*; apodeme *a2* nearly twice length of *st1*, *a1* and *a2* free posteriorly; apodemata *a4* united in midline and join sternum *st2*; apodemata *a5* weak, join in midline to form *st2*; *st2* contiguous with *st3*; *st3* and *st4* continuous. Coxal discs small and equal. Suctorial plate with irregular anterior margin. *Dorsum*. — Smooth except for single line



of sculpturing on anterior margin of propodosoma. Setae short, hair-like, and equal. *Legs.* — Tarsi I-II relatively short; otherwise leg size and shape, and leg setae size and arrangement similar to *H. julorum*, except: *ta15* legs I-II unstalked, membranous, wide at base, with rounded tips; *ta16* legs III-IV broad at base, but finely tapering; leg I *ta2-ta3* less than one-half length of *ta1*; legs I-II seta *f* longer.

*Remarks.* — Features most useful in identifying this species are expanded fused pedipalps equal in length to pedipalpal setae, arrangement of apodemata, small coxal discs, and shape of suctorial plate; dorsum smooth with single line sculpturing on anterior propodosoma, short equal setae; leg setae *ta15* I-II membranous, *ta2* and *ta3* leg I short.

*Collections.* — Collected by A. C. Oudemans on stretches between Wai Eno and Wai Temun, Insel Buru, February, 1921.

*Types.* — No record.

*Histiostoma trichophorus* (Oudemans), 1912

(Plate 49)

*Anoetus trichophorus* Oudemans, 1912; *Histiostoma trichophorus* (Oudemans), 1912 [Buitendijk, 1945].

*Female.* — No information.

*Male.* — No information.

*Deutonymph.* — (Plate 49). Length 0.175 mm.; width 0.108 mm. *Venter.* — Fused pedipalps equal in length to tibia I; pedipalpal setae equal to tarsus II. Sternum *st1* free posteriorly; apodemata *a4* joined in midline and united with *a2*; sternum *st2* extended anteriorly to united posterior portion of *a4*; apodemata *a5* united in midline with *st2* and *st3*. Coxal disc *di1* lies on *a2*, is slightly smaller than *di2* and *di3*. Suctorial plate ellipsoidal. *Dorsum.* — Smooth. Setae hairlike, generally equal or longer than tibia I, except *do3*, *do4*, and *do6* which are much shorter. Seta *dp3* slightly shorter than *dp4*. *Legs.* — Leg size, shape, and setae size and arrangement similar to *H. julorum*, except: *ti2* leg II much longer; *ta4* leg IV shorter, leg IV without claw.

*Remarks.* — Features most useful in identifying this species are length of fused pedipalps and pedipalpal setae *pp1*, arrangement of apodemata, shape of suctorial plate, hairlike dorsal setae generally as long or longer than tibia I. Vitzthum (1923) described an anoetid which he called *H. trichophorus* Oud. although there was some doubt in Vitzthum's mind that his specimens corresponded exactly with this species. In some features his specimens resembled *H. himalayae*. A similar form with pit-

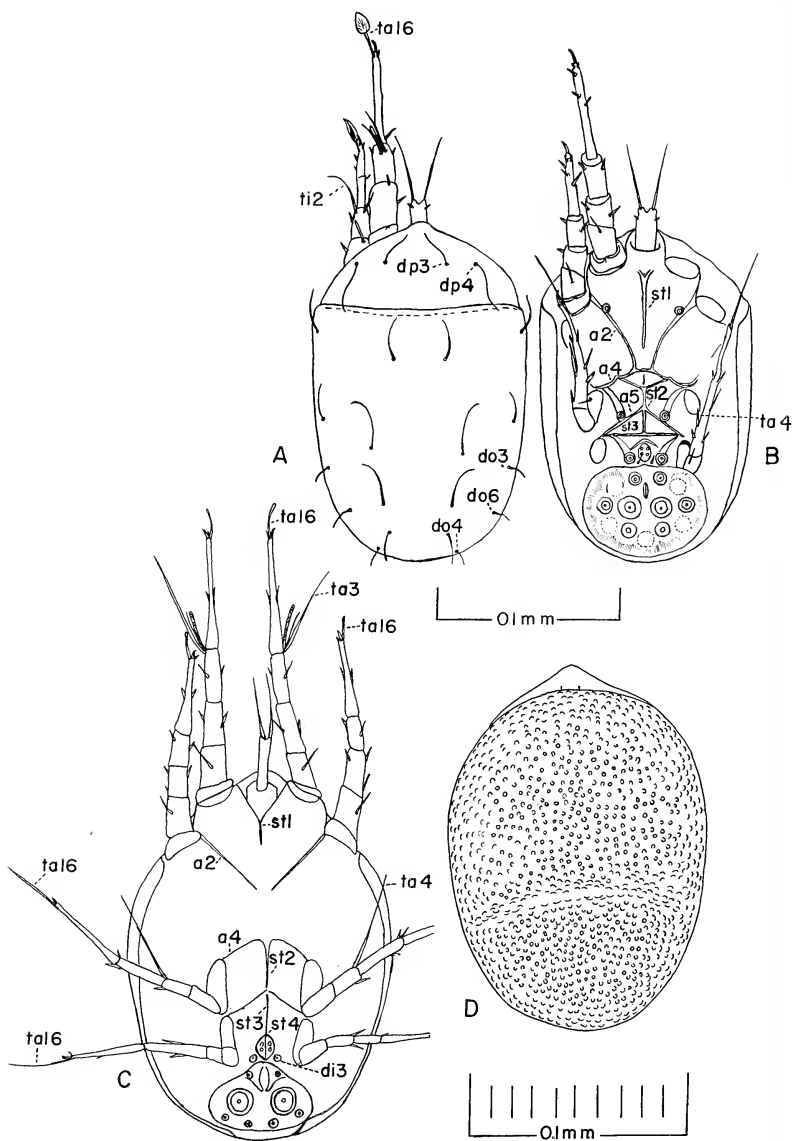


Plate 49 — Upper, *Histiotostoma trichophorus* deutonymph. A — dorsum. B — venter. (Original unpublished drawing by A. C. Oudemans) Lower, *Anoetostoma oudemansi* deutonymph. C — venter. D — dorsum. (After Womersley)

ted dorsal hysterosoma was also observed by Vitzthum in 1921.

*Collections.* — Collected by A. C. Oudemans on *Platypus dispar* Schauff II (Platypodidae), Mkulumusi Mountain, near the Biological Agricultural Institute, Amani, Dutch East Africa, July, 1911; by Vitzthum in Blankenese, Holstein, August, 1911; by H. Wichmann on *Dendroctonus micans* Kug., wood farm on the Thaya, July, 1920; by Vitzthum on *Hormocerus reticulatus* at Sumbava, Dutch Indies; by A. Krausse under bark of decaying tree trunk at Eberswalde, April, 1921.

*Types.* — Holotype in Natural History Museum at Hamburg, Germany.

#### GENUS *Anoetoglyphus* Oudemans, 1927

*Diagnosis of genus.* — Diagnosis is based on deutonymph (Oudemans, 1929). Coxa I with distinct disc *di1*; coxa III devoid of either a disc or seta. Coxa IV with disc *di3*. Suctorial plate with 2 functional suckers, 2 large central discs, and 4 small discs. (Oudemans 1927, Vitzthum 1927).

*Type.* — *Anoetoglyphus ateuchi* Oudemans, 1927.

#### *Anoetoglyphus ateuchi* Oudemans, 1927

*Female.* — No information.

*Male.* — No information.

*Deutonymph.* — (No published figure). *Venter.* — Coxa I with disc *di1*; coxa III devoid of a disc or seta. Coxa IV with disc *di3*. The row of 4 small discs on the suctorial plate is posteriad of the large central discs. Suctorial plate sucker-disc arrangement is then by rows 2.2.4, not 2.4.2 as in many anoetids. *Dorsum.* — Propodosoma smooth. Hysterosoma with extremely fine pores. Dorsal setae short. *Legs.* — Tarsal setae *ta16* legs I and II leaf-shaped; seta *ta16* leg III palette-shaped; leg IV without long *ta16*.

*Remarks.* — Because of the variability of the sucker-disc arrangement on the suctorial plate within the single genus *Anoetus*, for example, it is doubtful that the arrangement 2.2.4 will have diagnostic value for this genus, as Oudemans suggests.

*Collections.* — On larva of *Ateuchus semipunctatus* F., South Italy.

*Types.* — In Oudemans' collection (one slide with 4 deutonymphs sent to Oudemans by Vitzthum).

GENUS *Anoetostoma* Womersley, 1941

*Diagnosis of genus.* — Diagnosis is based on deutonymph. Coxa I and III devoid of either discs or setae. Coxa IV with disc *di3*. Suctorial plate with two functional suckers, 2 large central discs, and 4 small discs. (Womersley states that no dorsal sulcus is present, yet in figure he clearly shows a coarsely granular hysterosoma and a short smooth propodosoma, thus indicating a sulcus is actually present.)

*Type.* — *Anoetostoma oudemansi* Womersley, 1941.

*Anoetostoma oudemansi* Womersley, 1941

(Plate 49)

*Female.* — No information.

*Male.* — No information.

*Deutonymph.* — (Plate 49). Length 0.165 mm.; width 0.126 mm. *Venter.* — Fused pedipalps equal to length of tibia I. Suctorial plate ellipsoidal with two functional suckers, not described by Womersley but shown in his figure. Suctorial plate sucker-disc arrangement is 2.2.4 as in *Anoetoglyphus ateuchi* rather than 2.4.2 as in many other anoetids. Sternum *st1* short, not touching apodeme *a4*. Apodemata *a4* continuous in midline with sternum *st2*. Sterna *st2*, *st3*, and *st4* continuous. *Dorsum.* — Evidence of dorsal sulcus as described for genus. Hysterosoma coarsely granular. Dorsal setae probably minute, not observed by Womersley. *Legs.* — All tarsi with small claws. Tarsal setae *ta16* legs I-II clavate, legs III-IV *ta16* more than four times as long as claw; leg IV *ta4* unusually long.

*Remarks.* — The functional suckers were not recognized by Womersley. In all observed anoetids these are often distended in such a position as to be difficult to observe. In view of lack of many details in Womersley's description of *Anoetostoma oudemansi*, it is believed that setae on coxae I-III, and seta *vm1* associated with coxal disc *di3*, may have been present but not observed because of their minute size. If such setae are observed in the future by more detailed study, then this species would be placed in the genus *Anoetus*. However, since the presence of such setae is conjectural at this time, the genus *Anoetostoma* is retained. It may be noted that many leg setae are not shown. Features useful in identifying the deutonymph of this species are as follows: length of fused pedipalps and seta *ppl*, arrangement of apodemata, arrangement of suctorial plate, granular dorsum, short propodosoma, leg I *ta3* longer than tarsus II, and leg IV *ta4* exceptionally long.

*Collections.* — On *Musca domestica*, Sidney, New South Wales, June, 1940.

*Types.* — Probably in museum in Adelaide, Australia.

KEY TO THE SPECIES OF THE GENUS *Anoetus* BASED ON  
MALES

- 1. With a pair of postero-marginal seta longer than hysterosoma ..... *A. nepenthesiana*  
Without extremely long postero-marginal setae ..... 2
- 2. Pedipalpal seta *pp1* long, flagella-like; longer than tarsus I ..... *A. bushlandi*, sp. nov.  
Pedipalpal seta *pp1* shorter than tarsus I ..... 3
- 3. Dorsal hysterosomal setae of unequal length; seta *dm1* one-half, or less, length of others ..... *A. gibsoni*  
Dorsal hysterosomal setae approximately equal in length ..... *A. laboratorium*

KEY TO THE SPECIES OF THE GENUS *Anoetus* BASED ON  
FEMALES

- 1. Pedipalpal seta *pp1* very long, flagella-like, longer than tarsus I ..... *A. bushlandi*, sp. nov.  
Pedipalpal seta *pp1* shorter than tarsus I ..... 2
- 2. Claws long, tapering; over one-half length of tarsus I ..... *A. gibsoni*  
Claws short, stout; length less than one-fourth tarsus I ..... *A. laboratorium*

KEY TO THE SPECIES OF THE GENUS *Anoetus* BASED ON  
DEUTONYMPHS

- 1. Apodemata *a2* not continuous with apodemata *a4* ..... 8  
Apodemata *a2* continuous with apodemata *a4* ..... 2
- 2. Sternum *st1* continuous with apodemata *a4* ..... 3  
Sternum *st1* not continuous with apodemata *a4* ..... 5
- 3. Most dorsal setae, long, hairlike ..... *A. polynesiacus*  
Most dorsal setae short ..... 4

4. Plate disc *pd1* much larger than functional sucker *su*; tarsus III with paired distal membranous structure ..... *A. turcastanae*  
 Plate disc *pd1* almost equal in size to functional sucker *su*;  
 tarsus III without paired distal membranous structure ..... *A. heliocopridis*
5. Dorsal hysterosoma smooth ..... 6  
 Dorsal hysterosoma striated or shagreened ..... 7
6. Leg IV with typical claw ..... *A. conclavicola*  
 Leg IV without typical claw ..... *A. alicola*
7. Leg IV without typical claw ..... *A. laboratorium*  
 Leg IV with typical claw ..... *A. bushlandi*, sp. nov.
8. Apodemata *a5* free, not meeting to form *st2* ..... *A. gibsoni*  
 Apodemata *a5* not free, meeting to form *st2* ..... *A. nepenthesiana*

#### GENUS *Anoetus* Dujardin, 1842

*Diagnosis.* — Diagnosis is based on deutonymph. Coxae I and III with minute setae. Coxa IV with seta *vm1*, mesiad of disc *di3*. Suctorial plate with two functional suckers, two large central discs, and four small discs. (Oudemans, 1929; Gervais, 1844).

*Type.* — *Anoetus alicola* (Dujardin), 1849.

*Anoetus laboratorium* (Hughes), 1950, new combination

(Plates 50, 51)

*Histiostoma laboratorium* Hughes, 1950

*Female.* (Plate 50). Length 0.460 mm.; width 0.310 mm. *Venter.* — Chelicera serrated, bearing approximately eight teeth equal in length, with blunt or rounded ends; toothed region bearing seta-like structure ending in minute but distinct knob. Lateral chelicercal flagellum equal in length to toothed region. Pedipalpal seta *pp1* slightly longer than *pp2*. Laterally pedipalps bear many fine bristle-like structures. By comparison with *H. julorum* the following outstanding differences may be noted: setae more spine-like, except *vo3*; ring-like structures *r2* somewhat smaller, often almost triangular in shape, but variable in different specimens. *Dorsum.* — Smooth except rostrum, which is granular giving sculptured effect. Setae longer than tarsus I, tapering, except setae *dp1*, *dp2*, and *dp3*. Bursa copulatrix on line between excretory pores; slightly raised from surface of dorsum with opening in middle. Dorsal pits as in

*H. julorum*. *Legs.* — Leg shape, setae number, and arrangement similar to *H. julorum*, except seta *t* legs I-III nearly twice as long, leg I *g3*, *g4*, *ti2*, *ta1*, *ta2* and *ta6* larger; leg II *ti2* larger.

*Male.* — (Plate 50). Length 0.380 mm.; width 0.230 mm. Distinctly broad and shield-shaped. *Venter.* — Gnathosoma same as in female. By comparison with *H. julorum*, seta *vp1* shorter; *vm2* closer to lateral margin of coxa III; *vo2* more minute; *vo3* shorter; ring-like structures *r1* more widely separated, near coxae III, *r2* more widely separated, on level with posterior end of anus. Sclerotized structure associated with *a8*. *Dorsum.* — Smooth, except rostrum which is granular and sculptured, similar to female. Number, arrangement, and size of setae similar to female. *Legs.* — By comparison with female *A. laboratorium* and with male *H. julorum*, legs distinctly more massive; number of setae same; arrangement of setae similar, but generally much heavier. Legs IV extended posteriorly and apparently functionless as walking appendages, but used to grasp female during copulation.

*Deutonymph.* — (Plate 51). Length 0.180 mm.; width 0.140 mm. Color pink. *Venter.* — Pedipalpal seta *pp1* longer than tarsus I. Fused pedipalps short, barely extending beyond propodosoma. Coxae I and III setae extremely minute and difficult to see. Coxal IV seta *vm1* extremely minute, mesiad of *di3*. Apodemata *a1* with heavy anterior supporting processes lateral to gnathosomal base; sternum *st1* not making contact with apodemata *a4*; apodeme *a2* joining *d4*; apodemata *a4* continuous in midline; sternum *st2* faintly Y-shaped anteriorly, not joining *a4*; suctorial plate nearly rectangular, and without radial striations marginally. *Dorsum.* — Propodosoma smooth; hysterosoma striated or pitted; setae small, spine-like. Propodosomal setae equal in length; hysterosomal setae one-half length of similar setae in *H. julorum*. *Legs.* — Setae arrangement and number typical. By comparison with *H. julorum* there are the following striking differences: leg I seta *f* three times as long, *g2* finer, *ta3* longer, *ta15* small, difficult to see; leg II *f* longer, *ta16* tapering, not lancet-like. Leg IV *ta4* and *ta7* much shorter. What appears to be the longer terminal *ta16* leg IV is believed to represent an extremely modified claw, a condition more extreme than that found in *Anoetus gibsoni*. Seta *ta16* is thought to be represented by one of the smaller distal setae. Leg IV is usually extended posteriorly in an immobile position, and is essentially non-functional.

*Remarks.* — The combination of adult characteristics most useful in identifying this species is as follows: serrated chelicera with blunt teeth; knobbed seta on distal chelicera; short pedipalpal seta; bristle-like structures associated with pedipalps; for the female nearly triangular discs *r2* with setae *vm3* posterior and lateral; small rounded bursa copulatrix on a line with seta *dol1*; for the male position of seta *vm1* antero-laterad of

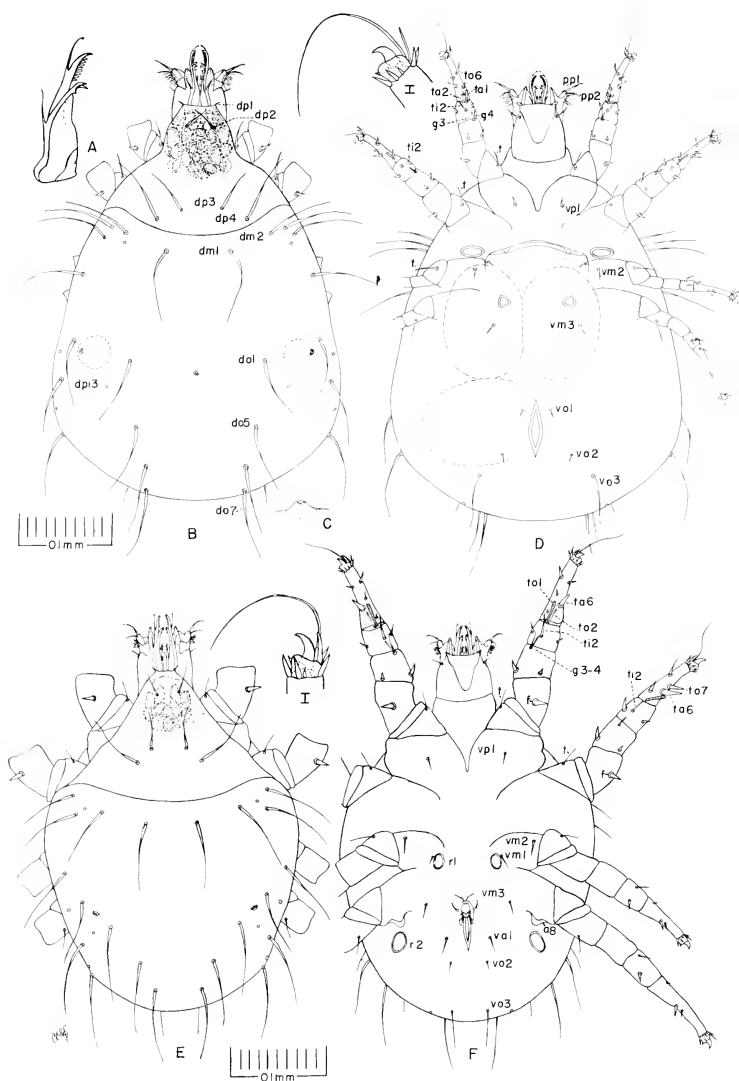


Plate 50 — *Anoetus laboratorium*. A — chelicera. B — female, dorsum. C — bursa copulatrix. D — female, venter. E — male, dorsum. F — male, venter.



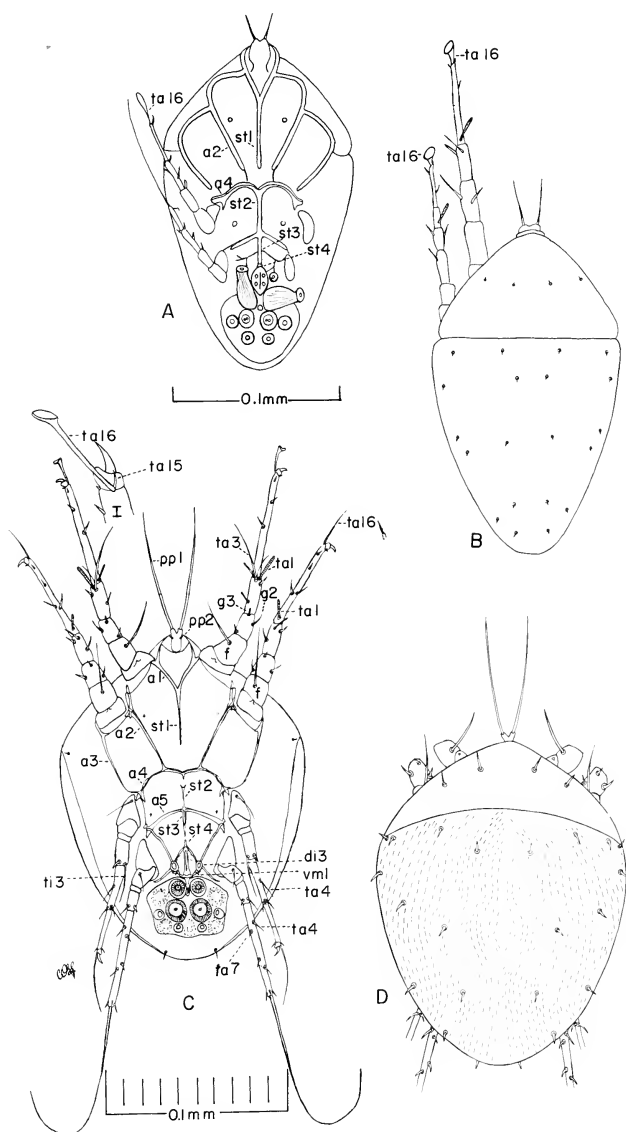


Plate 51 — Upper, *Anoetus alicola* deutonymph. A — venter. B — dorsum.  
 (After Dujardin) Lower, *Anoetus laboratorium* deutonymph.  
 C — venter. D — dorsum.

*r1*, and *vm3* opposite the anterior end of external genitalia; position of *r2* posterior to sclerotized apodeme *a8*, and leg IV functionless as a walking appendage; for the deutonymph pitted hysterosoma, arrangement of apodemata, shape of suctorial plate, size of disc *di3*; leg IV without claw and with long "end hair," functionless as a walking appendage. Studies show that the life cycle may be completed within five days. The short life cycle plus the fact that the deutonymph appears to be very hardy, can make this species a serious pest in *Drosophila* cultures as well as a frequent contaminant in mite cultures. The haploid number of chromosomes is 4. It is interesting to note that although this species is very hardy and prolific, it has not been observed in the hundreds of collections made by us. It might be surmised that it is not a native of Eastern United States but of some distant area, and that it has been distributed by exchange of *Drosophila* cultures from one laboratory to another. This species is named "*laboratorium*" because of its occurrence in laboratory *Drosophila* cultures. It is arrhenotokous.

*Collections.* — 1945 *Drosophila* culture obtained from a biological supply house in Chicago, Illinois; 1951 *Drosophila* culture furnished by J. Novikoff, Baltimore, Maryland; 1952 collected in England by A. M. Hughes.

*Types.* — Holotype and paratypes in U. S. National Museum, Washington, D. C. Paratypes located as follows:

U. S. National Museum, Washington, D. C.

British Museum of Natural History, London, England

Rijksmuseum van Natuurlijke Historie, Leiden, Netherlands

Museum National d'Histoire Naturelle, Paris, France

The South Australian Museum, Adelaide, South Australia

Natal Museum, Pietermaritzburg, Union of South Africa

National Collection, Ottawa, Canada

USSR Academy of Science, Moscow and Leningrad, USSR

Musee Royal d'Histoire Naturelle de Belgique, Brussels, Belgium

*Anoetus alicola* (Dujardin), 1849

(Plate 51)

*Hypopus alicola* Dujardin, 1849; *Anoetus alicola* (Dujardin), 1849, [Oudemans, 1924c]; *Anoetus discrepans* Oudemans, 1903.

*Female.* — No information.

*Male.* — No information.

*Deutonymph.* — (Plate 51). Length 0.126-0.248 mm.; color brownish; shape oval, elongate. *Venter.* — Fused pedipalps expanded in mid-region, barely extending beyond propodosoma; breadth almost equal to length; pedipalpal seta *pp1* slightly longer than fused pedipalps. Coxae I and III with small structures assumed to be setae which Oudemans (1903) described as rudimentary sucking discs. Coxa IV with disc *di3*. Sternum *st1* not making contact with apodemata *a4*. Apodeme *a2* faintly continuous with *a4*. Apodemata *a4* continuous in midline. Sternum *st2* continuous with *a4* and *a5*. Sterna *st3* and *st4* continuous. *Dorsum.* — Dorsum smooth; setae minute. *Legs.* — Seta *ta16* I-II spoon-shaped; seta *ta16* leg III more spatulate; leg IV with "end hair" as long as last four joints. Tarsi I-III with minute claws.

*Remarks.* — Because of the unusually small size of the coxal I and III structures, it is believed that they are actually the bases of minute setae rather than discs or rudimentary suckers as Oudemans suggests. Although the possession of coxal I and III setae and *vm1* located mesiad of disc *di3* are diagnostic characters of the genus *Anoetus*, both are usually minute and often very difficult to observe. Oudemans does not show either type of seta, but on the basis of other general characters, as well as their assumed presence in this instance, we are placing this species in the genus *Anoetus*. Many leg setae are not shown and were probably overlooked. It should be noted that the "end hair" on tarsus IV is probably not *ta16* but rather a highly modified claw as in *A. laboratorum*. We have reproduced Oudemans' figure of *A. discrepans* instead of Dujardin's original drawing. Features most useful in identifying the deutonymph of this species are short fused pedipalps and seta *pp1*, arrangement of apodemata, shape of suctorial plate, minute equal dorsal setae, spoon-shaped *ta16* legs I-II, spatulate *ta16* leg III and long "end hair" leg IV.

*Collections.* — Collected by Dujardin on wing of bee, from Saint-Gaudens (Haute-Garonne), France, 1849; by Oudemans on *Halictus notatus* K, near Bremen, Germany, 1903.

*Types.* — In Oudemans' collection (*A. discrepans*).

*Anoetus bushlandi*, sp. nov.

(Plates 52, 53)

*Female.* — (Plate 52). Length 0.425 mm.; width 0.260 mm. *Venter.* Chelicera finely and uniformly serrated, with approximately eight teeth; lateral chelicercal flagellum about three times length of toothed region. Pedipalpal seta *pp1* laterally directed, trailing, over five times length of *pp2*. Small thin leaf-like structures project laterally from the labium.

Ringlike structures small; *r1* elliptical and heavily chitinated; *r2* more rounded. Setae small, hairlike. Seta *vo3* twice as long as other ventral setae and about one-half as long as *vo3* of *A. laboratorium*. Seta *do7* marginal. *Dorsum*. — Smooth except for sculptured rostrum. All setae including *dp3* and *dp4* as long or longer than combined length of genu, tibia, and tarsus of leg I, except *dp1* and *dp2*. Position and size of bursa copulatrix similar to that of *A. laboratorium* except not raised from surface of dorsum. *Legs*. — By comparison with *A. laboratorium* trochanter setae *t* leg I-III and femoral seta *f* leg IV much shorter; position and arrangement of other leg setae similar.

*Male*. — (Plate 52). Length 0.290 mm.; width 0.165 mm. *Venter*. — Gnathosoma as in female. Setae small, hairlike, variable in length. Seta *vm1* posteriad of anterior ringlike structure *r1*; *r2* opposite apodeme *a8*. *Dorsum*. — As in female, except seta *do7* is missing. *Legs*. — In contrast to *A. laboratorium* tarsus I seta *ta6*, tarsus II *ta6* and *ta7* less robust; trochanter setae *t* legs I-III, and femoral seta *f* leg IV one-half as long.

*Deutonymph*. — (Plate 53). Length 0.167 mm.; width 0.131 mm. More oval in shape than *A. laboratorium*. *Venter*. — Fused pedipalps similar in size and shape to *A. laboratorium*. Pedipalpal seta *ppl* slightly more than half length of tarsus I. Coxae I, III, IV setae minute as in *A. laboratorium*. Coxa IV disc *di3* small, about one-half diameter of suctional plate disc *pd2*. Arrangement of apodemata similar to *A. laboratorium*, except sternum *st2* is continuous with apodemata *a4*, and *st3* ends in an inverted "Y" posteriorly. Suctional plate distinctly indented laterally; central *pd1* almost twice diameter of functional sucker *su*. *Dorsum*. — Finely shagreened, except for anterior membranous margin of propodosoma; setae minute and hairlike. *Legs*. — All legs with claws. By comparison with *A. laboratorium*, seta *ta16* leg I spoon-shaped but smaller; seta *ta15* lancet-shaped and longer; seta *ta16* leg II lancet-like; femoral setae *f* legs I-II one-half as long; tarsal setae *ta4* and *ta7* leg IV much longer. Leg III *ta16* approximately four times length of claw; leg IV *ta16* as least six times as long as claw.

*Remarks*. — The combination of adult characteristics most useful in identifying this species is as follows: finely serrated chelicera; extremely long *ppl*; small nearly round ringlike structures; uniformly long dorsal seta, except *dp1* and *dp2*; *dp3* and *dp4* long and equal; for the female *vm3* posterior to *r2*, and small unraised bursa copulatrix on lines between setae *do1* and *do5*; for the male position of setae *vm1* posterior to *r1*, and *vm3* antero-mesial of *r2*. The deutonymph characteristics most useful for identification are shagreened dorsum; membranous anterior extension of propodosoma; hairlike dorsal setae; extremely small disc *di3*; laterally indented suctional plate; large disc *pd1*; arrangement of apodemata; and

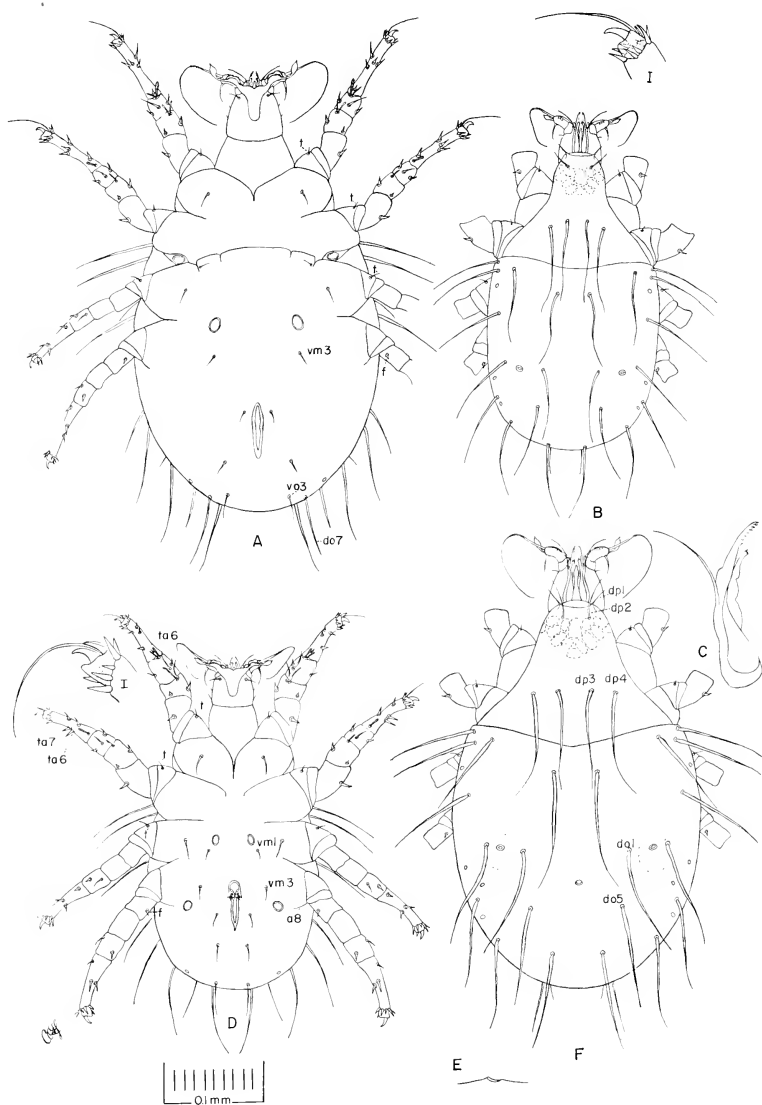


Plate 52 — *Anoetus bushlandi*. A — female, venter. B — male, dorsum. C — chelicera. D — male, venter. E — bursa copulatrix. F — female, dorsum.

length of leg IV *ta16*. The shape of suctorial plate with lateral indentations is unique among all the anoetids so far examined. This species is ar-rhenotokous. Named in honor of R. C. Bushland.

*Collections.* — Collected by O. Schomberg, on stable fly media, Kerrville, Texas, November, 1951; by R. C. Bushland, on stable fly media, Kerrville, Texas, April, 1952.

*Types.* — Holotype and paratypes in U. S. National Museum, Washington, D. C. Paratypes located as follows:

U. S. National Museum, Washington, D. C.  
British Museum of Natural History, London, England  
Rijksmuseum van Natuurlijke Historie, Leiden, Netherlands  
Museum National d'Histoire Naturelle, Paris, France  
The South Australian Museum, Adelaide, South Australia  
Natal Museum, Pietermaritzburg, Union of South Africa  
National Collection, Ottawa, Canada  
USSR Academy of Science, Moscow and Leningrad, USSR  
Musée Royal d'Histoire Naturelle de Belgique, Brussels, Belgium

*Anoetus conclavicola* Oudemans, 1929

(Plate 53)

*Female.* — No information.

*Male.* — No information.

*Deutonymph.* — (Plate 53). Length 0.170 mm.; width 0.110 mm. Color yellowish brown. *Venter.* — Fused pedipalps similar to *A. laboratorium* except seta *pp1* is only slightly longer than tibia I, and is blunt at end. Sternum *st1* not making contact with apodemata *a4*; apodeme *a2* making contact with *a4*; apodemata *a4* continuous in midline, and making contact with sternum *st2*; sterna *st2-st4* continuous. Coxa I and III setae minute and club-shaped. Coxa IV seta *vm1* small spine-like, mesiad of disc *di3*. Suctorial plate large and ellipsoid. Disc *pd1* twice diameter of sucker *su*. *Dorsum.* — Indications of faint sculpturing on propodosoma. Setae equal, minute and fine. *Legs.* — Leg I seta *ta16* spoon-shaped, *ta15* large unstalked, palette-shaped, *ta1* nearly one-half length of tarsus I; leg II *ta16* short, club-shaped, seta *ta15* unstalked, palette-shaped; seta *f* legs I-II long as in *A. laboratorium*; leg III *ta16* long, lancet-shaped; seta *ti3* shorter than *A. laboratorium*, seta *ta4* equal in length to *ta16*; leg IV *ta16* longer than leg, seta *ta4* and *ta7* distinctly longer than corresponding setae in *A. laboratorium*.

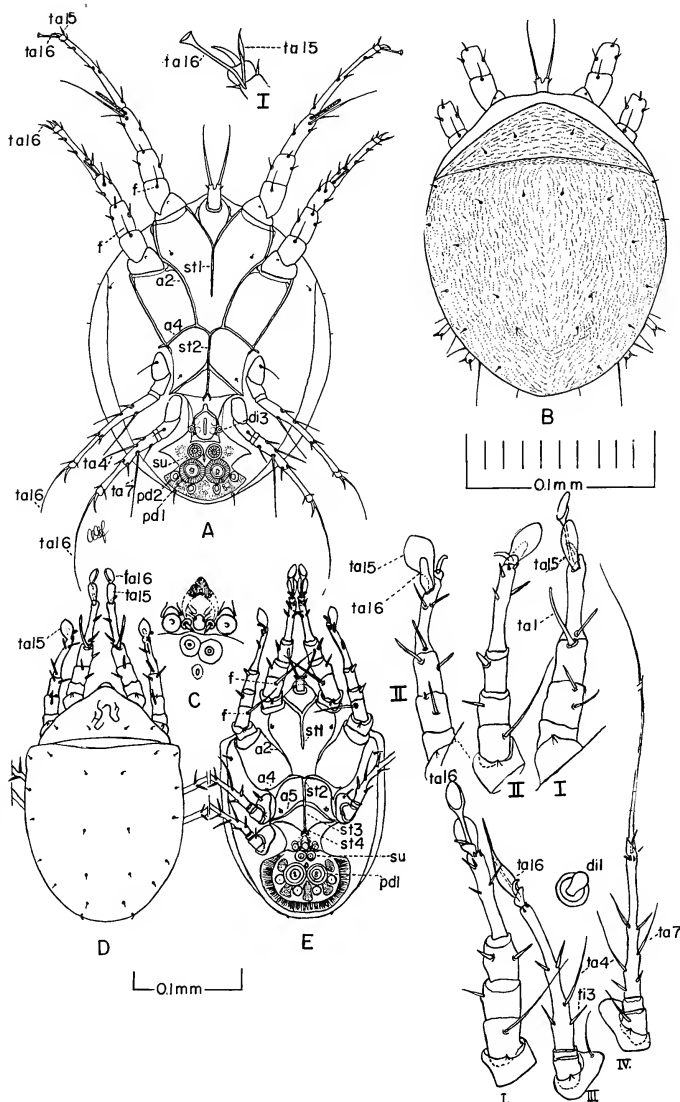


Plate 53 — Upper, *Anoetus bushlandi* deutonymph. A — venter. B — dorsum. Lower, *Anoetus conclavicola* deutonymph. C — discs *di3* and associated area. D — dorsum. E — venter. Right, legs I-IV and seta *dil*. (Original unpublished drawing by A. C. Oudemans)

*Remarks.* — Blunt pedipalpal setae *pp1* have not been observed in any anoetid studied in detail. Its presence in this species may be due to breakage, or if confirmed would have diagnostic value. The unusual club-shaped setae on coxae I and III are also peculiar to this species. Because of the extreme smallness of these coxal setae in general their exact shape is more often than not open to some doubt (cf. *A. gibsoni*). Generally conspicuous leg setae which are not shown in Oudemans' drawings are as follows: tarsus I setae *ta2* and *ta3*; tarsus III *ta6*. Features most useful in identifying this species are as follows: short fused pedipalps, arrangement of apodemata, minute equal dorsal setae, *ta16* leg I spoon-shaped, *ta16* leg II club-shaped, *ta16* leg III long lancet-shaped, *ta16* leg IV exceptionally long and tapering.

*Collections.* — Collected by A. Collart on *Koptorthosoma nigrita* Fabr. Stanleyville, Belgian Congo, 1928.

*Types.* — In Musee du Congo — Belge, Tervueren, Belgium.

*Anoetus gibsoni* (Nesbitt), 1954, new combination

(Plates 54, 55)

*Zwickia gibsoni* Nesbitt, 1954.

*Female.* — (Plate 54). Length 0.435 mm.; width 0.280 mm. *Venter.* — Chelicera finely serrated with approximately twenty-two teeth, diminishing in size distally; cheliceral flagellum nearly twice length of serrated portion. Pedipalpal seta *pp1* directed anteriorly and laterally, over twice length of *pp2*. Seta *pp2* minute, fine, and directed mesially. Ventral setae fine, varying in length. In comparison with *A. laboratorium* seta *vp1* hairlike, three times as long; *vm2* further posteriad of ringlike structure *r1*, hairlike and twice as long; seta *vm3* almost contiguous mesially with ringlike structure *r2*, hairlike and twice as long; *vo1*, *vo2* and *vo3* short, equal in length and more closely grouped around anus; marginal seta *do7* more ventral in position. Ringlike structures ovoid; posterior pair *r2* more widely separated than in *A. laboratorium*. Two mesial pit-like structures located slightly posteriad of vulva. *Dorsum.* — Propodosoma separated from hysterosoma by faint sulcus. Dorsum smooth, except for faintly granular rostrum. Setae generally stout and distinctly variable in length. In comparison with *A. laboratorium* setae *dp3*, *dm1*, *dm2* and *do1* shorter. Dorsal pit-like structures same as for *A. laboratorium* except *dpi3* appears to be missing. Position of bursa copulatrix nearly on line with setae *do5*. *Legs.* — By comparison with *A. laboratorium* all legs are longer. Leg setae in general are outstandingly heavier and longer, less curved and tapering.



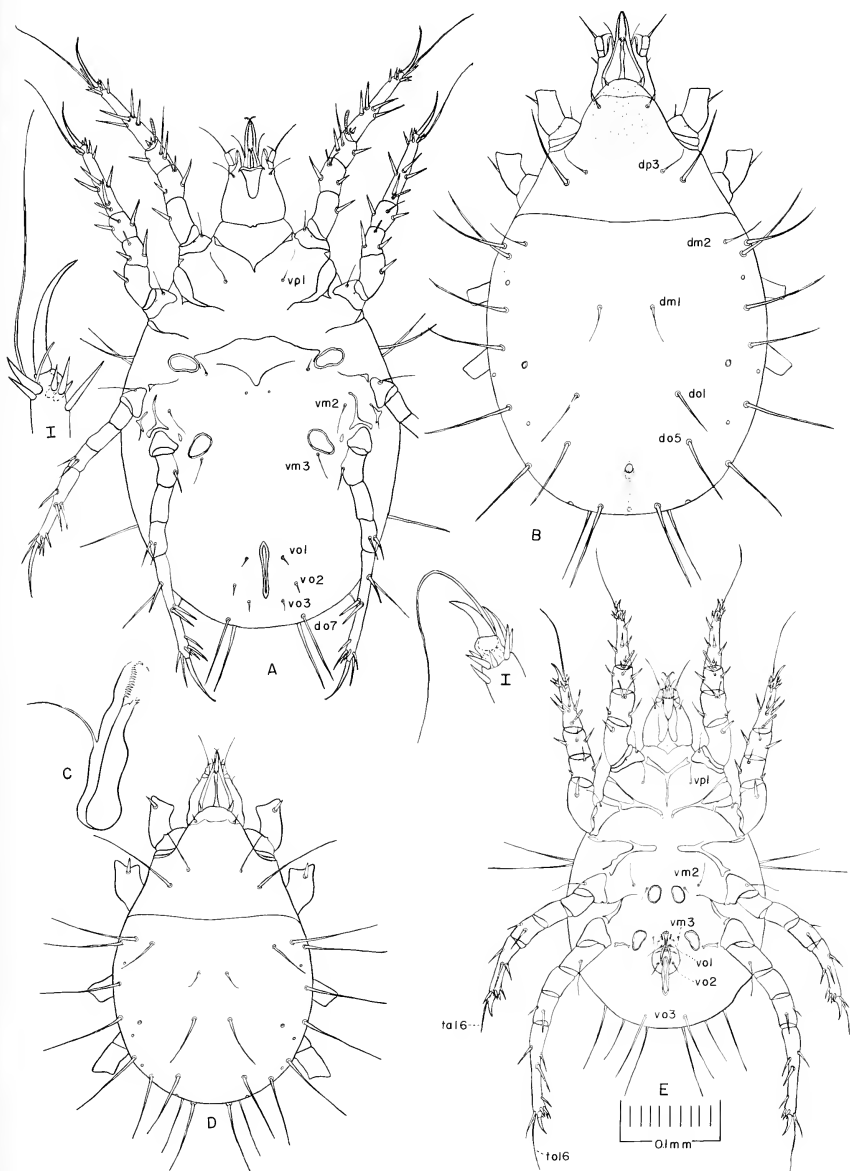


Plate 54 — *Anoetus gibsoni*. A — female, venter. B — female, dorsum. C — chelicera. D — male, dorsum. E — male, venter. (Modified after Nesbitt)

*Male*. — (Plate 54). Length 0.300 mm.; width 0.200 mm. *Venter*. — Gnathosoma as in female. Pedipalpal seta *pp2* extremely minute or absent (see under remarks). Ventral setae variable in length, and fine except *vo3*. In comparison with *A. laboratorium* seta *vp1* hairlike, almost twice as long; *vm2* almost twice as long and more distant from trochanter III; *vm3* closer to genital apparatus and mesiad of ringlike structure *r2*; *vo1* and *vo2* borne on genital plate, and anterior to anus; *vo3* twice as long and heavier; anterior ringlike structures *r2* ovoid, closer together and on level with external genitalia; genitalia and a portion of anus associated with a conspicuous genital plate. *Dorsum*. — Smooth, except for faintly sculptured rostrum. Pit-like structures and setae essentially as in female. *Legs*. — setae arrangement similar to female, but setae generally smaller. Outstanding exceptions are as follows: seta *ta16* leg III twice length of claw; *ta16* leg IV over three times length of claw; claws shorter and heavier than in female.

*Deutonymph*. — (Plate 55). Length 0.259 mm.; width 0.200 mm. Unusually broad in region of opisthosoma. *Venter*. — Fused pedipalps almost three times as long as wide, and extending well beyond propodosoma. Pedipalpal seta *pp1* equal to combined length of genu I and tibia I. Posterior ends of sternum *st1* and apodemata *a2* on a line, and do not meet *a4*; apodemata *a4* extend anteriorly and do not make contact in midline; apodemata *a5* and sternum *st3* extend anteriorly with ends free. Coxae I and III with minute, peg-like setae. Coxae IV and seta *vm1* hairlike, twice length of coxae I and III setae. Suctorial plate ellipsoid, relatively small; functional suckers *su* equal in diameter to central disc *pd1*. *Dorsum*. — Smooth, except for faint transverse sculpturing on propodosoma. Setae fine, minute, and equal. *Legs*. — Seta *ta16* leg I spoon-shaped; leg II *ta16* lancet-shaped; legs III-IV *ta16* long, tapering. All legs with claws. Setae generally prominent. In comparison with *A. laboratorium* setae *f* leg I-II shorter; setae *tal* legs I-II much larger; seta *ta4* leg III much longer; seta *f* leg IV shorter; setae *ta4* and *ta7* leg IV much longer. Claws long, slender and slightly curved.

*Remarks*. — This species is unusual in that in the adult female pedipalpal seta *pp2* is directed mesially. In the male this seta is extremely minute, and is not certainly present, although in one or two specimens it appeared to be present. Nesbitt claims that it is absent. A faint dorsal sulcus can be seen in both male and female. Nesbitt does not describe a sulcus for either male or female, nor does he show one in his figure. The presence of a pair of pit-like structures posteriad of the vulva is unique except for *Z. quentheri* in comparison with all other anoetids we have studied in detail. These pit-like structures are somewhat smaller than the dorsal pit-like structures and for this reason may not be comparable.

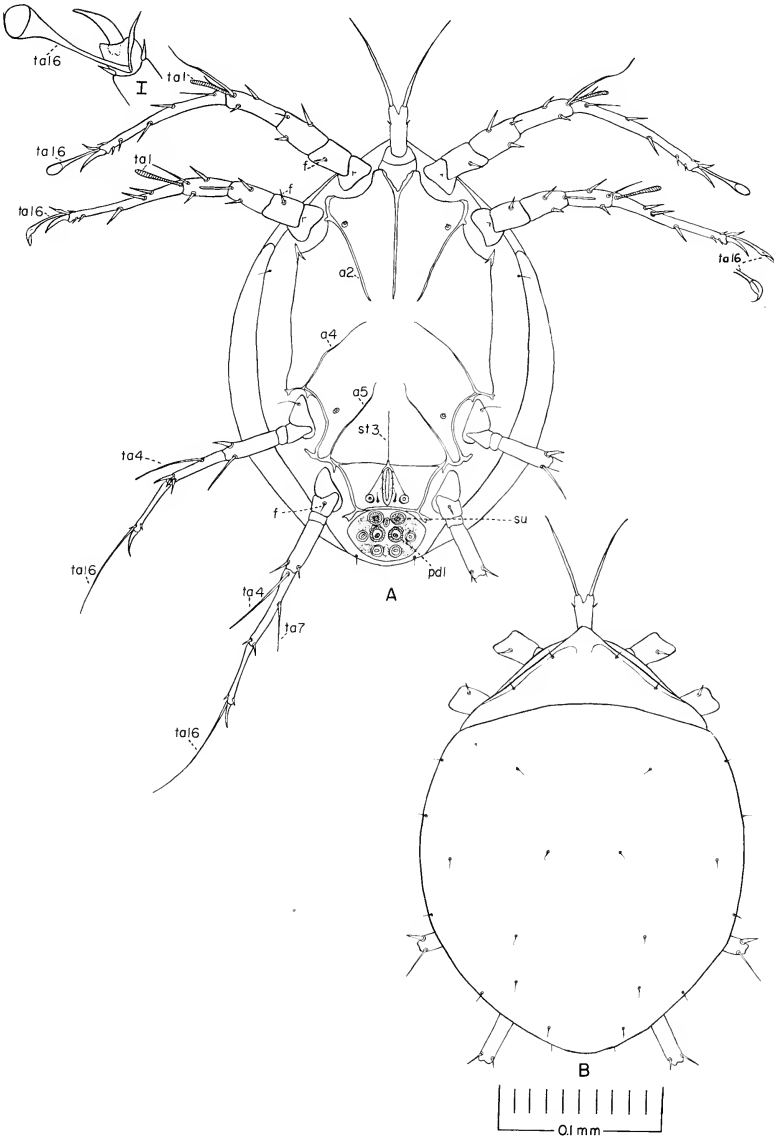


Plate 55 — *Anoetus gibsoni* deutonymph. A — venter. B — dorsum. (Modified after Nesbitt)

The bursa copulatrix is much more posterior in position than for *A. laboratorium* and *A. bushlandi*. The leg setae of this species are unusually stout and clear, and are useful in confirming the setal pattern for other species in which there is some doubt about the presence of a few minute setae. The claws of the female are unusually long and almost spine-like in shape. We have placed this species in the genus *Anoetus* because it shows all the necessary diagnostic features including a faint dorsal sulcus in the adult, although it must be admitted that it also has many features at present considered to be characteristic of other species of the genus *Zwickia*. Among such features may be mentioned: the arrangement of the anal setae of female, the unusually long claws of the adults, the small suctorial plate, and arrangement of apodemata in the deutonymph. Specimens for study were kindly furnished by Dr. Nesbitt.

*Collections.* — Collected by H. H. J. Nesbitt in pitchers of *Sarracenia purpurea* L. from sphagnum bogs at Glengarne (Danford Lake, Aylwin Township, Gatineau County, Quebec).

*Types.* — In Nesbitt's collection.

*Anoetus heliocopridis* Vitzthum, 1926

(Plate 56)

*Female.* — No information.

*Male.* — No information.

*Deutonymph.* — (Plate 56). Length 0.157 mm.-0.169 mm.; width 0.099 mm.-0.104 mm. Color pale yellow. *Venter.* — Fused pedipalps equal length of tibia I, extending about one-half length beyond propodosoma. Seta *pp1* equal length of tarsus II. Sternum *st1*, and apodemata *a2* and *a3* make contact with apodemata *a4*; apodemata *a4* continuous in midline; sternum *st2* faintly continuous with apodemata *a4* and continuous with *a5*; sternum *st3* makes contact with apodemata *a5*, but is not in contact with *st4*. Coxae I and III with minute setae; coxa IV with fine seta, mesiad of small discs *di3*. Suctorial plate ellipsoidal. *Dorsum.* — Hysterosoma finely honey-combed anteriorly and more longitudinally striated posteriorly; propodosoma smooth. Dorsal setae short and fine. *Legs.* — Tarsal setae *ta16* legs I-II lancet-shaped with definite midrib; *ta16* leg III tapered, almost three times length of claw; *ta16* leg IV tapered, over four times length of claw; seta *ta3* leg I longer than tarsus. In comparison with *A. laboratorium* the following differences are noted: leg I *f* spine-like, about one-third as long; leg II seta *f* about one-half as long.

*Remarks.* — The description above is based primarily on Oudemans'

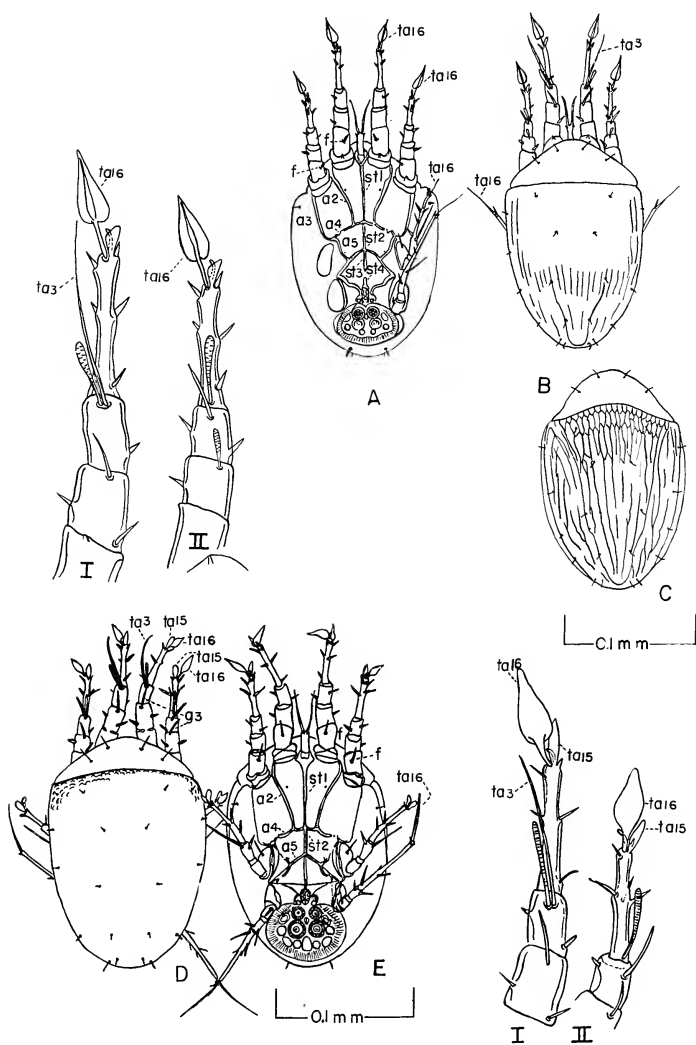


Plate 56 — Upper, *Anoetus heliocopridis* deutonymph. Left, legs I-II. A — venter. B — dorsum. C — dorsum of another specimen in which striations were more definite. (Original unpublished drawing by A. C. Oudemans) Lower, *Anoetus turcastanae* deutonymph. D — dorsum. E — venter. Right, legs I-II. (Original unpublished drawing by A. C. Oudemans)

(1916) original drawings and to a lesser degree on Vitzthum's (1926b) description of this species. Vitzthum's drawings differ from Oudemans' in one or two possibly important respects, as follows: Vitzthum does not show a sculptured hysterosoma, and his drawing of the suctorial plate is almost round instead of ellipsoidal. If these differences are accurately shown it is possible that they were dealing with closely related, but different species. It may be noted that Oudemans does not show all of the leg setae typical for anoetids. It is assumed that the missing setae were overlooked. Features most useful in identifying this species are as follows: length of fused pedipalps and setae *pp1*, arrangement of apodemata, hysterosoma longitudinally striated, dorsal setae short and fine, *ta16* legs I-II lancet-shaped, *ta16* legs III-IV tapering.

*Collections.* — Collected by H. J. Veth on *Helicopris bucephalus*. Fabricus, February 20, 1903, in Java; by Paravicini near Lembang, Java, July, 1921.

*Types.* — In Oudemans' collection in Arnhem.

*Anoctus nepenthesiana* (Hirst), 1928, new combination

(Plate 57)

*Zwickia nepenthesiana* Hirst, 1928.

*Female.* — (No figure). Length 0.370 mm. *Venter.* — Ringlike structures larger and more elongated than in male; position of these structures apparently typical for female anoetids. Terminal posterior setae shorter than in the male. *Legs.* — The legs and leg setae are weaker than in the male; claw of leg I longer and more slender.

*Male.* — (Plate 57). Length 0.340 mm.; width 0.225 mm. *Venter.* — Pedipalpal setae *pp1* and *pp2* apparently minute. Details of gnathosoma not clear from Hirst's description. Propodosomal seta *vp1* equal to genu I; metapodosomal seta *vm1* less than one-half length of *vp1*, lateral to and almost contiguous with anterior ringlike structure *r1*; *vm2* slightly longer than *vp1*, and on coxa III; *vm3* equal to *vm1*, and mesiad of posterior ringlike structure *r2*; *vo2* longer than *vm2*, and posterior to anus; *vo3* nearly equal length of leg III. Ringlike structures ellipsoid; structures *r1* close together and nearly on a line between trochanters III; structures *r2* more widely spaced and on a line between trochanters IV. *Dorsum.* — (No figure). Dorsum smooth; setae fine, much shorter than exceptionally long *vo3*. *Legs.* — All legs with strong spines. Tarsi II-III with terminal group of stout spines. Claw I short and stout, claws II-IV long, slender and slightly curved; claw IV shorter than II and III.

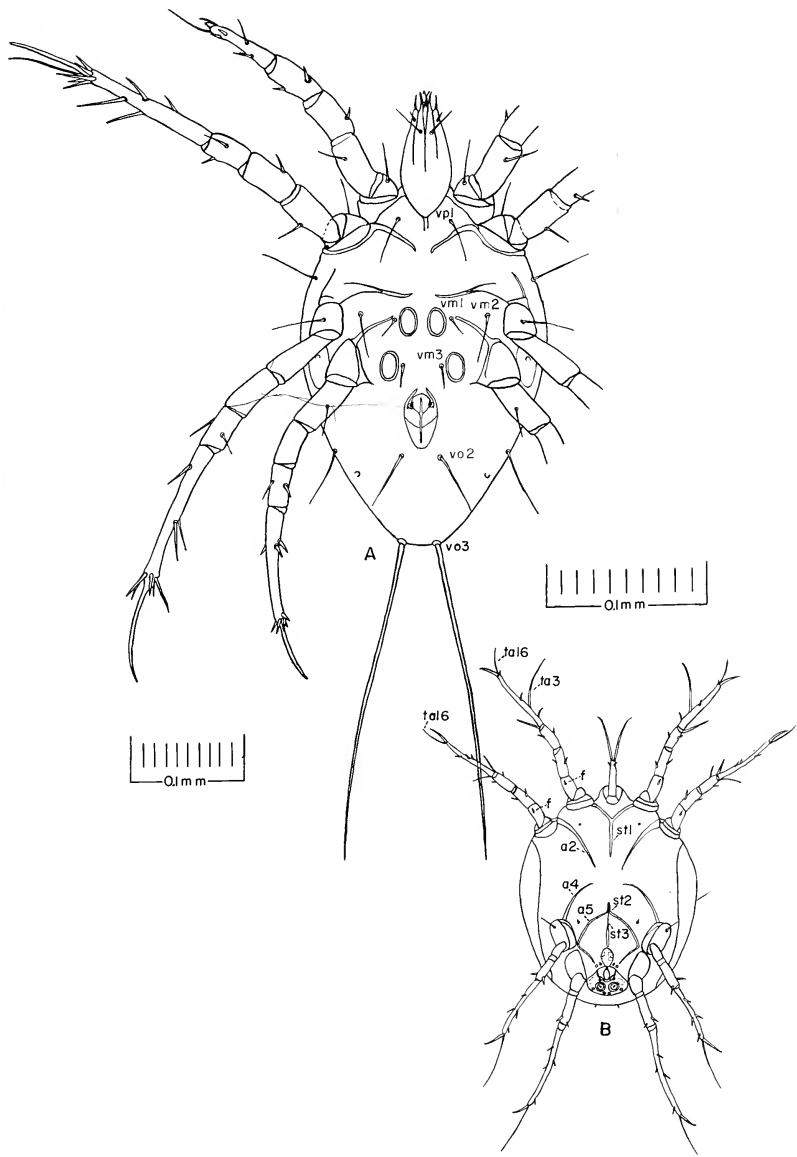


Plate 57 — *Anoetus nepenthesiana*. A — male, venter. B — deutonymph, venter. (After Vitzthum)

*Deutonymph.* — (Plate 57). Length 0.210 mm.; width 0.100 mm. *Venter.* — Fused pedipalps long, slender and extending well beyond propodosoma; pedipalpal setae *pp1* longer than fused pedipalps. Sternum *st1*, and apodemata *a2* and *a4* free in mid-region; apodemata *a5* join in midline to form a short sternum *st2*, which is continuous with *st3*. Coxa I with minute structure, assumed to be seta; coxa III with minute seta. Coxa IV with minute seta mesiad of the extremely small disc *di3*. Suctorial plate almost triangular in shape, with four extremely small posterior discs. *Dorsum.* — No information. *Legs.* — All legs with long, slender and slightly curved claws. Terminal tarsal setae *ta16* all legs long, tapering. Setae *f* legs I-II short. Seta *ta3* leg I as long as tarsus.

*Remarks.* — In Hirst's drawing of the venter of the male, a pair of opisthosomatic pit-like structures are shown laterad of seta *vo2*. No such structures have been seen in this position on the venter of the males of other anoetids. However, they would fit the position of other species if they were dorsal instead of ventral. That Hirst is showing both dorsal and ventral structures is indicated by the fact that he shows the excretory pores in the same drawing. Many leg setae apparently have been overlooked. Hirst's drawing definitely is that of the male, as his description also indicates, but was labeled in error a female. Vitzthum when republishing this figure omitted the genitalia, and called it a tritonymph, presumably because of the position of the ringlike structures which is more characteristic of the tritonymph than the female. Hirst's drawing of the deutonymph clearly shows coxa III with minute seta. Coxa I, however, is shown without a definite seta, but merely a dot which could represent either a minute disc, or seta. Vitzthum's modification of Hirst's drawing represents the structure on coxa I as a minute disc, and coxa III with a minute seta, and calls attention to this observation in the text. If Vitzthum's observations are correct a new genus would have to be established. In view of Vitzthum's uncertainty as to whether or not the structure on coxa I is truly a disc, and also in view of the difficulty of observing coxal setae in other species, the view is taken here that coxa I has a seta rather than a disc. Thus the presence of setae on coxae I and III instead of discs, and the position of seta *vm1* mesiad of disc *di3* places this species in the genus *Anoetus* instead of *Zwickia*. Hirst's drawing of the deutonymph shows apodemata *a5* not continuous in midline. Vitzthum on closer examination of the apodemata states that *a5* are actually continuous in midline. This point of view is accepted here. Since both Vitzthum and Hirst have overlooked many leg setae, it is possible that the details of setae *ta16* legs I-II may not be accurately represented. It is more likely that they are spoon-shaped, or lancet-like, as in most anoetids, rather than tapering. It is of interest that *A. nepenthesiana* and *A. gibsoni* have a number of characteristics in common with *Z. guentheri*, such as long slightly curved claws and in the migrant a small suctorial



plate and free apodemata.

*Collections.* — Found by Mr. C. Boden Kloss and Mr. Cedric Dover in the pitchers of *Nepenthes ampullaria*, in the jungle around Thompson Road Reservoir, Singapore. It appears that Vitzthum (1931) examined specimens of this species which were not the same as Hirst's original material, but the source is not given. Collected by investigators in *Nepenthes gymnamphora* pitchers in Sumatra and Java in 1931.

*Types.* — No record.

*Anoetus polynesiacus* Vitzthum, 1920

(Plate 58)

*Female.* — No information.

*Male.* — No information.

*Deutonymph.*—(Plate 58). Length 0.155 mm.; width 0.097 mm. Shape nearly oval, with pointed end posteriorly. Color pale yellow. *Venter.* — Fused pedipalps less than one-half length of tarsus II, wider at base, and not extending to end of propodosoma. Pedipalpal seta *pp1* equal to length of tarsus II. Apodemata *a1* short, joining anteriorly to form sternum *st1*. Sterna *st1*, *st2* and apodemata *a2* unite with apodemata *a4*, which latter are continuous in midline. Sternum *st2* with faint wing-like lateral extensions; *st2* and *st3* are continuous, and united with apodemata *a5*. Coxae I and III with minute structures, assumed to be setae. Coxa IV with large and distinct disc *di3*. Suctorial plate ellipsoid. The four posterior and lateral plate discs *pd2* and *pd3* equal in size to sucker *su*. *Dorsum.* — Dorsum smooth; setae hairlike, and varying in length. Lateral propodosoma seta *dp4* about one-third length of median pair *dp3* which is longer than tibia I; all hysterosomal setae longer than median propodosomal setae *dp3* except setae *do5* which is equal in length to *dp3*, and *do4* and *do6* which are equal in length to *dp4*. *Legs.* — Tarsal setae *ta16* legs I-II spoon-shaped. Setae *ta16* legs III-IV comparatively short and tapering. Seta *ta3* leg I nearly equal to tarsus I. All legs with small but distinct claws.

*Remarks.* — Vitzthum states that the minute structures on coxae I and III appear to be faintly developed suckers, but that this is not at all certain. The position is taken here, as in *A. alicola*, that these structures are actually the bases of minute setae. It seems likely that these setae as well as the small setae *vm1* mesiad of the discs *di3*, were overlooked by Vitzthum, since they are difficult to observe in other species of genus *Anoetus*, and since such minute discs without setae have not been ob-

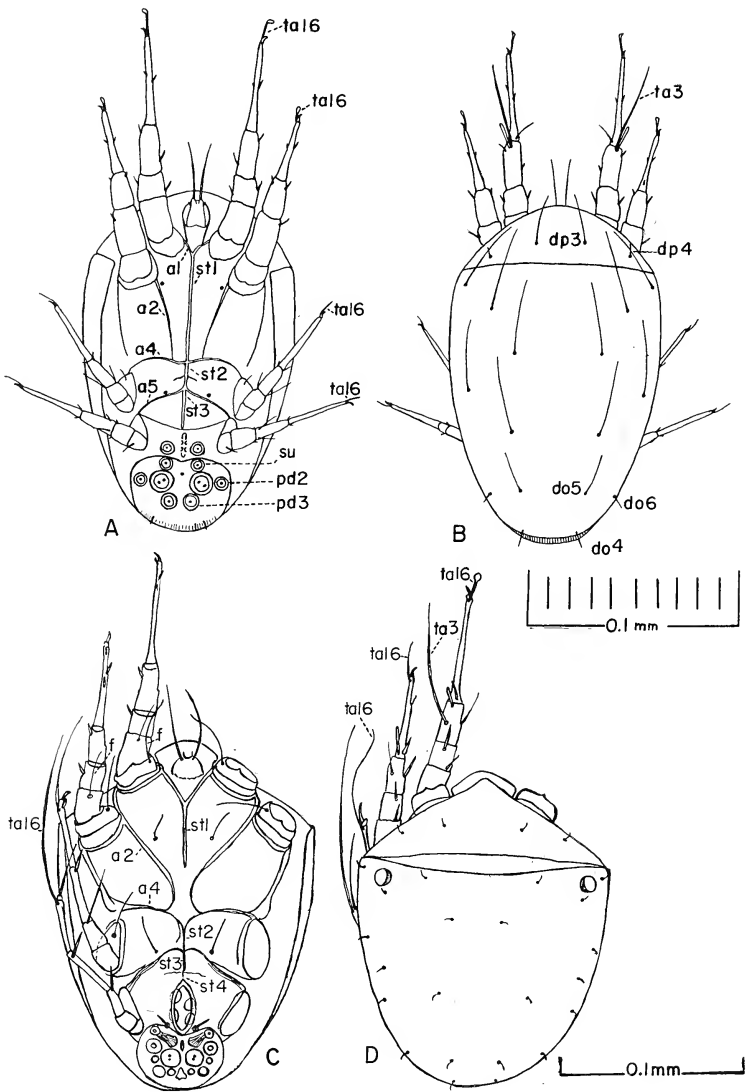


Plate 58 — Upper, *Anoetus polynesiacus* deutonymph. A — venter. B — dorsum. (After Vitzthum) Lower, *Bonomoia primitiva* deutonymph. C — venter. D — dorsum. (Original unpublished drawing by A. C. Oudemans)

served with certainty in any anoetids. On the basis of the usual setae pattern for the deutonymph, setae *dm5* and *do3* were apparently overlooked by Vitzthum. It also appears that Vitzthum missed a number of leg setae. Features most useful in identifying this species are as follows: short fused pedipalps, arrangement of apodemata, dorsal setae hairlike and varying in length, *ta16* legs I-II spoon-shaped, *ta16* legs III-IV short and tapering.

*Collections.* — Discovered by Vitzthum on the beetle *Eubactrus semiaeneus* Lacord. Supplied by R. Kleine from Fiji Islands.

*Types.* — In Vitzthum's collection.

*Anoetus turcastanae* Oudemans, 1917

(Plate 56)

*Female.* — No information.

*Male.* — No information.

*Deutonymph.* — (Plate 56). Length 0.165 mm.; width 0.110 mm. *Venter.* — Fused pedipalps approximately equal to genu I, barely extending beyond propodosoma; pedipalpal seta *pp1* equal to tarsus I. Sterna *st1*, *st2* and apodemata *a2* unite with apodemata *a4*, which latter are continuous in midline. Sterna *st2* and *st3* continuous and united with apodemata *a5*; *st3* and *st4* appear to be faintly continuous. Coxae I and III with faint structures which are assumed to be minute setae; coxa IV with disc *di3*. Suctorial plate large, ellipsoid. *Dorsum.* — Dorsum smooth except for faintly shagreened anterior portion of the hysterosoma. Hysterosomal setae minute and equal, about one-third of the length of propodosomal setae. *Legs.* — Tarsal seta *ta16* legs I-II lancet-like; seta *ta15* lancet-like but shorter and more blunt. Tarsus III bears a pair of membranous structures assumed to correspond to *ta16*, and an extension of claw base. Seta *ta16* leg IV long and tapering, equal to pedipalpal seta *pp1*. Seta *f* legs I-II about half length of *A. laboratorium*; seta *g3* legs I-II more than twice length. Seta *ta3* leg I longer than tarsus I. All legs with small claws.

*Remarks.* — Apparently Oudemans overlooked seta *vm1*, which for this genus should be mesiad of disc *di3*. Oudemans has missed only a few leg setae. The terminal tarsal membranous structures of leg III are worthy of note since such structures appear to be unique among the anoetids. Features most useful in identifying this species are as follows: length of fused pedipalps and seta *pp1*, arrangement of apodemata, shagreened anterior hysterosoma, *ta16* legs I-II lancet-shaped, leg III with a pair of membranous structures terminally, and *ta16* leg IV long and tapering.

*Collections.* — Found on *Homalocopris tmolus* Fisch. by H. J. Veth, in Turkestan, February, 1903.

*Types.* — No record.

GENUS *Bonomoia* Oudemans, 1911

*Diagnosis of genus.* — Diagnosis is based on deutonymph. Coxa I and III with prominent hairlike seta; suctorial plate with two functional suckers, two large central discs, and four small marginal discs. One pair of translucent cuticular elevations, giving the appearance of "eyes" located on the anterio-lateral margins of the dorsal hysterosoma.

*Type.* — *Bonomoia primitiva* Oudemans, 1911.

*Bonomoia primitiva* Oudemans, 1911

(Plate 58)

*Female.* — No information.

*Male.* — No information.

*Deutonymph.* — (Plate 58). Length 0.187 mm.; width 0.140 mm. *Venter.* — Fused pedipalps equal to genu I; pedipalpal seta *pp1* two-thirds length of tarsus I. Sternun *st1* free posteriorly; apodeme *a2* S-shaped, curved posteriorly to join *a4*; *a4* curve posteriorly in midline to join *st2*. Venter described as pitted, but not shown in figure. *Dorsum.* — Dorsum pitted, with "eyes" as described for genus; setae minute, hairlike, and equal. Pedipalpal base extends anteriorly beyond propodosoma. Pitted dorsum described but not shown in figure. *Legs.* — Seta *ta16* leg I small spoon-shaped; *ta16* leg II tapering; *ta16* leg III tapering and longer than *pp1*; *ta16* leg IV tapering and longer than entire leg IV. The seta presumed to be *ta3* leg I arises from tibia and is longer than tarsus I. Claw III longer and heavier than claws I-II. Claw IV elongated. Femoral setae *f* legs I-II are long and hairlike, nearly as long as *pp1*.

*Remarks.* — Features most useful in identifying this species other than those diagnostic for the genus are as follows: short, wide, fused pedipalps; arrangement of apodemata; absence of coxal IV disc *di3*; pitted venter and dorsum; short equal dorsal setae; shape of *ta16* all legs; leg IV claw long and tapering; seta *ta3* leg I longer than tarsus. Named in honor of G. Cos. Bonomo.

*Collections.* — One specimen on a blattid with hard abdomen, collected by D. MacGillavry in Banjoewangi, Java, 1910.

*Types.* — Holotype in Oudemans' collection.

GENUS *Chiropteranoetus* Womersley, 1942

*Diagnosis of genus.* — Diagnosis is based on the deutonymph. Coxa I with strong, blunt seta, no disc; coxa III without disc, or seta. Coxa IV with short, blunt, spine-like process, and a fine seta *vm1* mesiad of this process. Suctorial plate with two functional suckers *su*; two large central discs *pd1*; and four spine-like processes in positions corresponding to discs *pd2* and *pd3*.

*Type.* — *Chiropteranoetus chalinolobus* Womersley, 1942.

*Chiropteranoetus chalinolobus* Womersley, 1942

(Plate 59)

*Female.* — No information.

*Male.* — No information.

*Deutonymph.* — (Plate 59). Length 0.300 mm.; width 0.195 mm. *Venter.* — Fused pedipalps longer than tibia I. Pedipalpal seta *pp1* approximately equal to tibia I; *pp2* nearly one-half as long as *pp1*. Suctorial plate small, almost round. Other characteristics as for genus. It should be noted that in Womersley's figure, the seta presumed to be coxa III seta is actually trochanter III seta *t* and is characteristic for this segment. If his figure is correct coxa III is without a seta or disc. *Dorsum.* — Dorsum smooth; setae hairlike, slightly variable in length. Seta *dp4* almost twice as long as *dp3*. *Legs.* — All tarsi with small claws, except tarsus IV, which has two terminal setae shorter than tarsus IV, a unique feature if correctly observed by Womersley.

*Remarks.* — Apodemata not shown. Structures which appear to represent small functional suckers *su* are shown by Womersley, but not described. Of interest is the similarity of the suctorial plate spines of this species and *Myianoetus undulatus*. Womersley describes, probably in error, six propodosomal setae instead of the usual four as for other anoetids. Many leg setae typical of this family are not shown by Womersley. Features useful in identifying this species are: long fused pedipalps, length of *pp1* and *pp2*, stout coxae I and IV setae, presence of suctorial plate setae, and dorsal setae hairlike and varying in length.

*Collections.* — A single specimen from residue in jar containing bats, *Chalinolobus gouldi*, probably from South Australia.

*Types.* — Probably in Museum in Adelaide, Australia.

GENUS *Glyphanoetus* Oudemans, 1929

*Diagnosis of genus.* — Diagnosis is based on the deutonymph. Coxa I without disc or seta; coxa III with disc *di2*; coxa IV with small seta *vm1* mesiad of disc *di3*; suctorial plate with two functional suckers, two large central discs, and four discs laterally and posteriorly.

*Type.* — *Glyphanoetus horridum* (Berlese), 1913.

*Glyphanoetus horridum* (Berlese), 1913, new combination

(Plates 60, 61)

*Histiostoma horridum* Berlese, 1913; *Glyphanoetus fulmeki* Oudemans, 1929.

*Female.* — (Plate 60). Length 0.250 mm.; width 0.160 mm. *Venter.*

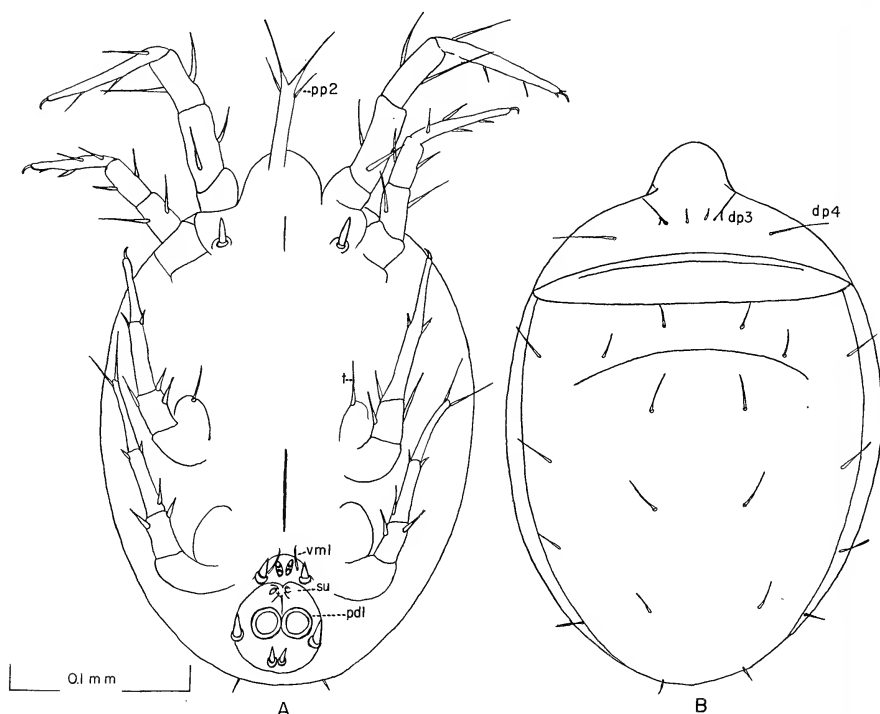


Plate 59 — *Chiropteranoetus chalinolobus* deutonymph. A — venter. B — dorsum. (After Womersley)

— Chelicera not serrated, distally enlarged, cup-shaped; cheliceral flagellum equal to seta *dm3*. Seta *pp1* over three times as long as *pp2*. Membrane associated with pedipalps prominent, projecting laterally and anteriorly. Ringlike structure *r1* smaller and more mesiad than *H. julorum*, *r2* nearly oval and lies close to anterior end of anus. Setae hairlike, variable in length. Seta *vm1* conspicuous. Definite anal plate bearing posterior ringlike structures and opisthosomatic setae. Seta *do7* on ventral surface posterior to anal plate. Without ventral pit-like structures *vpi1*. *Dorsum*. — Finely granular; rostrum faintly sculptured. Six pairs of unusually long, saber-shaped setae, borne on distinct bosses; other setae smaller, varying in length. Excretory pores on raised boss-like structures. Bursa copulatrix on level with excretory pores, boss-like and directed anteriorly. Without dorsal pit-like structures. *Legs*. — Leg setae similar to *H. julorum*. A most unusual feature is the extremely long saber-like seta *ti3* leg I. All legs slender; claw bases pointed, especially legs II-IV.

*Male*. — (Plate 60). Length 0.167 mm.; width 0.100 mm. *Venter*. — Gnathosoma same as female. Genital plate present with small ringlike structure *r1* on level with anterior margin, and *r2* on level with anterior end of anus and widely separated. Type of setae similar to female except more variable in size. Two pairs of fine setae-like genital spicules. Seta *do4* marginal instead of dorsal. Seta *dm3* anterior to *r2*. *Dorsum*. — Dorsum heavily sculptured. Setae *dm1*, *do1*, and *do5* reduced in comparison with female. Bosses conspicuous. No pit-like structures observed. *Legs*. — As in female except *tal* leg II longer, finer than *tal* leg I.

*Deutonymph*. — (Plate 61). Length 0.132 mm.; width 0.100 mm. *Venter*. — Fused pedipalps equal to tibia I. Seta *pp1* equal to tarsus II. Apodemata *a2* unite with *a4*; sternum *st1* free posteriorly, *st2* free anteriorly, and continuous with united apodemata *a5* and *st3* posteriorly. Other features as for genus. *Dorsum*. — Propodosoma faintly sculptured transversely. Anterior margin of hysterosoma striated, otherwise smooth. Propodosomal setae short, fine; hysterosomal setae variable in length, generally long, slender and flexible; *do4* and *do6* short. *Legs*. — Seta *tal6* leg II tapering, not spoon-shaped; *tal6* leg III-IV short.

*Remarks*. — Seta *ta3* leg I longer than tarsus II. Male small as compared with female; one of the most completely sculptured anoetids observed. Good slides of this species are difficult to prepare because of the extremely long saber-shaped setae. The non-serrated chelicerae are atypical. Vitzthum was shown *G. horridum* by Grandjean. This specimen was from Spain. Berlese saw only the female, and Oudemans only the deutonymph. Oudemans' deutonymph was described as having fine points on the hysterosoma and ten pairs of long setae instead of eight. These observations could not be confirmed. Features useful in identifying the adult of this species are non-serrated chelicera, length of pedipalpal se-

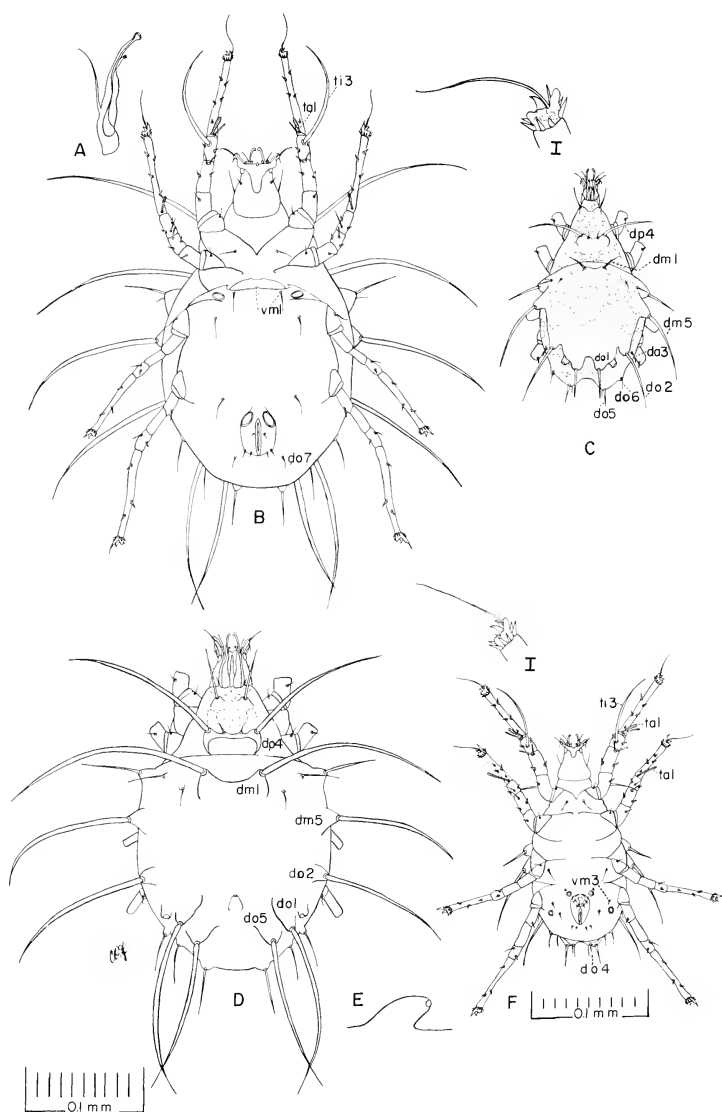


Plate 60 — *Glyphanoetus horridum*. A — chelicera. B — female, venter. C — male, dorsum. D — female, dorsum. E — bursa copulatrix. F — male, venter.



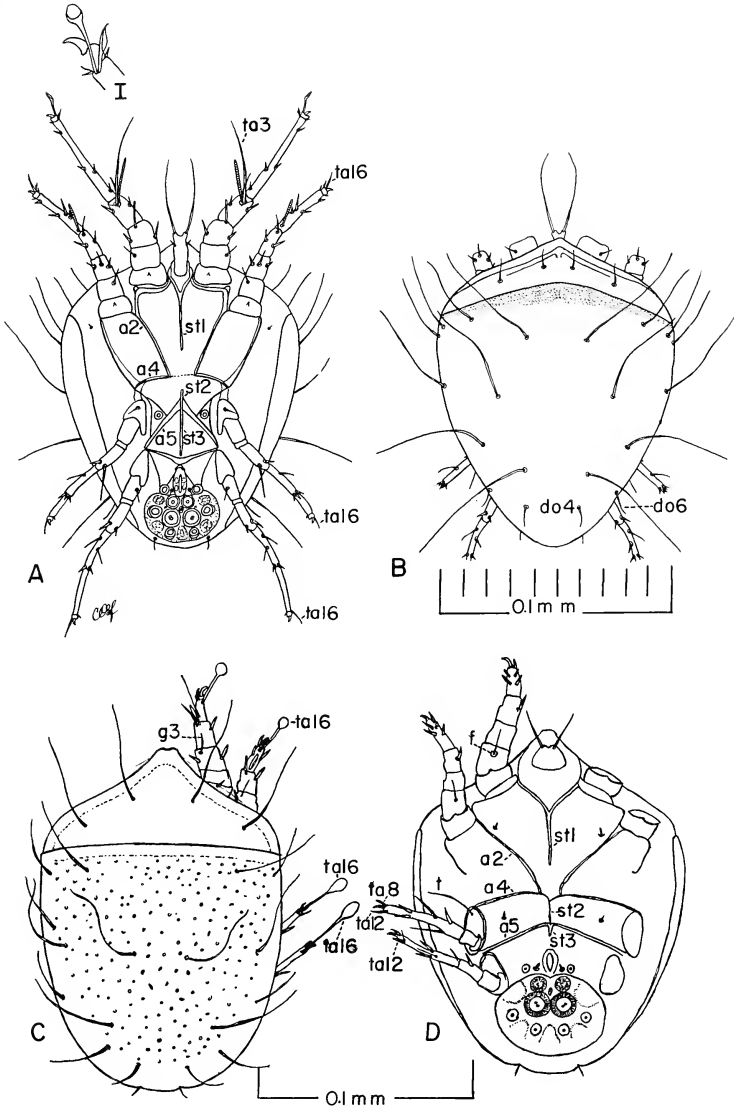


Plate 61 — Upper, *Glyphanoetus horridum*, deutonymph. A — venter. B — dorsum. Lower, *Lipstorpia mixta* deutonymph. C — dorsum. D — venter. (Original unpublished drawing by A. C. Oudemans)

tae, membranous structures associated with pedipalp, position of ringlike structures, saber-shaped setae borne on prominent bosses, claw bases extended and tapering above claw, and leg III *ti3* extremely long and heavy; for the deutonymph, length of fused pedipalps and seta *pp1*, arrangement of apodemata, long, hairlike dorsal setae, and shape of leg setae *ta16*.

*Collections.* — Collected by Jacobson in Java, 1913; by L. Fulmek in a vineyard near Weenen, Germany, 1929; by A. H. O'Bier at mouth of Cone River near Warsaw, Virginia, 1953.

*Types.* — Holotypes, no record. Plesiotypes (supplied by present authors) in U. S. National Museum, Washington, D. C. Plesiotypes in authors' collection.

#### GENUS *Lipstorpia* Oudemans, 1911

*Diagnosis of genus.* — Diagnosis based on deutonymph. Coxa I and III with small seta; coxa IV with small seta median to disc *di3*. Suctorial plate with two functional suckers, two large central discs, and four small discs. Legs I-IV with spoon-shaped terminal setae *ta16*.

*Type.* — *Lipstorpia mixta* Oudemans, 1911

*Lipstorpia mixta* Oudemans, 1911

(Plate 61)

*Female.* — No information.

*Male.* — No information.

*Deutonymph.* — (Plate 61). Length 0.166 mm.; width 0.118 mm. *Venter.* — Gnathosoma expanded; fused pedipalps broad at base, tapering anteriorly, width at base greater than length; pedipalpal seta *pp1* twice length of fused pedipalps. Sternum *st1* free posteriorly; apodeme *a2* faintly continuous with *a4*; apodemata *a4* slightly arched, continuous in mid-line and joining *st2*; apodemata *a5* continuous in midline and joining with *st2* and *st3*. Coxa I and III with small, thorn-shaped setae, coxa IV with small setae median to discs *di3*. *Dorsum.* — Propodosoma smooth, hysterosoma pitted. Setae hairlike and flexible; propodosomal setae equal to leg III less coxa; hysterosomal setae variable in length, generally long. *Legs.* — Tarsi I-II short, equal to tibia. By comparison with *H. julorum* the following setae differences are noted: leg I seta *f* longer, *g3* longer, mid-tarsal setae more closely grouped; leg II *ta16* spoon-shaped, mid-tarsal setae more closely grouped; leg III seta *t* long-

er, *ta8* and *ta12* equal length of claw, *ta16* spoon-shaped; leg IV *ta8* and *ta12* equal to claw, *ta16* spoon-shaped.

*Remarks.* — The combination of features most useful in identifying the deutonymph of this species is as follows: short laterally expanded fused pedipalps, length of *pp1*, arrangement of apodemata, coxa I, III, and IV with small setae; dorsally pitted hysterosoma, long dorsal setae; spoon-shaped terminal tarsal setae all legs, and extremely short tarsi legs I-II, a feature which Oudemans considers diagnostic for this genus. A number of leg setae are omitted or missing in comparison with *H. jolorum*. Oudemans in 1914c placed *H. brevimanus* and *H. crassipes* in the genus *Lipstorgia* and in 1917 these were placed under genus *Anoetus*.

*Collections.* — Two specimens collected by D. MacGillavry on a blattid with hard abdomen, Banjoewangi, Java, 1910.

*Types.* — Probably in Oudemans' collection.

#### GENUS *Mauduytia* Oudemans, 1929

*Diagnosis of genus.* — Diagnosis based on deutonymph. Coxa I and III without discs or setae; coxa IV with small seta *vm1* mesiad of disc *di3*. Suctorial plate with two functional suckers, two large central discs and four discs laterally and posteriorly.

*Type.* — *Mauduytia tropicus* (Oudemans), 1911

*Mauduytia tropicus* (Oudemans), 1911

(Plate 62)

*Anoetus tropicus* Oudemans, 1911; *Mauduytia tropicus* (Oudemans), 1911 [Oudemans, 1929].

*Female.* — No information.

*Male.* — No information.

*Deutonymph.* — (Plate 62). Length 0.156 mm.; width 0.110 mm. *Venter.* — Width of fused pedipalps one-half of length, length one-half of tarsus II; pedipalpal seta *pp1* longer than tarsus I. Sternum *st1* free posteriorly; apodeme *a2* united with *a4*; apodemata *a4* continuous in midline and united with *st2*; apodemata *a5* continuous in midline and united with *st2* and *st3*; *st3* divided; *st4* not shown. Suctorial plate functional suckers *su*, discs *pd2*, and *pd3* equal to coxal disc *di3*. *Dorsum.* — Smooth. Gnathosomal base extended anteriorly beyond propodosoma. Propodosoma

nearly rectangular, less than one-eighth length of entire soma. Setae minute, hairlike and equal in length. *Legs.* — Leg shape and setae arrangement similar to *H. julorum* except: setae *ta16* legs I-II lancet-shaped with definite midrib, leg III *ta16* short, and *ta16* leg IV equal in length to tibia and tarsus of leg IV; leg I setae *f* and *g3* longer, *ta3* longer than tarsus I; leg II *ti2* longer; leg III *ta4* short. A few typical leg setae are not shown in Oudemans' drawing.

*Remarks.* — In view of the difficulty of observing coxal setae I and III in some species of the genus *Anoetus* it is possible that these structures may have been overlooked. If such setae are discovered in future studies, then this species would fall into genus *Anoetus*. The extreme length of terminal tarsal seta *ta16*, leg IV is typical of most of the *Anoetus* species. Features most useful in identifying this species are as follows: length of pedipalpal setae, arrangement of apodemata, smooth dorsum, short, almost rectangular propodosoma, minute and equal dorsal setae, long *ta3* leg I, lancet-shaped setae *ta16* legs I-II, and extremely long *ta16* leg IV.

*Collections.* — One specimen collected by D. MacGillavry on a blattid with hard abdomen, Banjoewangi, Java, 1910.

*Types.* — No record.

#### GENUS *Myianoetus* Oudemans, 1929

*Diagnosis of genus.* — Diagnosis is based on the deutonymph. Suctorial plate with two functional suckers and two large discs. Claws of leg I-III cleft.

*Type.* — *Myianoetus muscarum* (Linnaeus), 1758.

*Remarks.* — Of the *Myianoetus* species so far described *M. filicum*, *M. muscarum*, *M. diadematus* are without coxal I and III discs or setae, *M. undulatus* has either vestigial discs or minute setae on coxa I and III, and *M. setipes* has minute coxal I and III setae. Only *M. filicum* has a conspicuous coxa IV disc. In addition to the functional suckers and large discs on the suctorial plate *M. undulatus* bears four thorn-like structures, *M. diadematus* two setae, *M. muscarum* two spine-like structures, and according to Tradgardh *M. setipes* bears four thorn-like structures. Hence, the common diagnostic features for this genus are those listed above.

*Myianoetus undulatus*, sp. nov.

(Plates 62, 63)

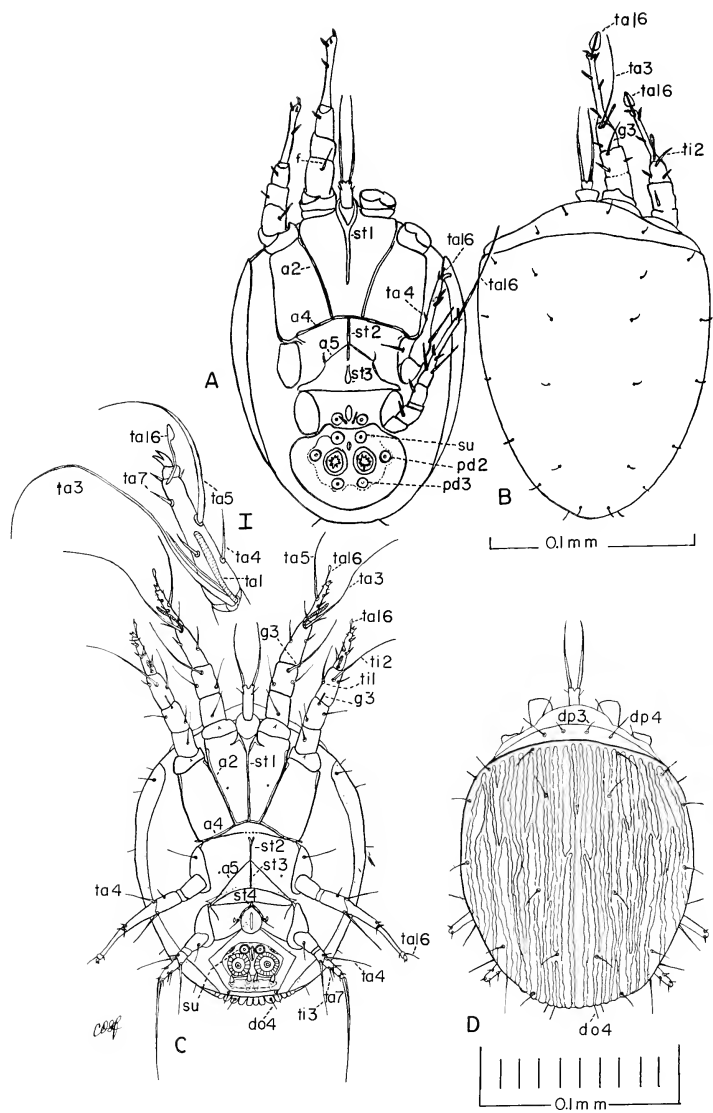


Plate 62 — Upper, *Mauduytia tropicus* deutonymph. A — venter. B — dorsum. (Original unpublished drawing by A. C. Oudemans) Lower, *Myianoetus undulatus* sp. nov. deutonymph. C — venter. D — dorsum.

*Female*. — (Plate 63). Length 0.380 mm.; width 0.280 mm. *Venter*. — Chelicera not serrated, tapering distally; median member of chelicera forked; cheliceral flagellum equal to typical dorsal metapodosomal seta. Pedipalp unusually long, surrounded by conspicuous membranous structure extending beyond distal end of pedipalp; *pp1* twice length of cheliceral flagellum, three times length of *pp2* which latter arises from subterminal position. Ringlike structures *r1* nearly round, and lying near midline. Genital opening inverted V-shape, with distinct supporting structure in midline easily mistaken for a longitudinal opening. Ringlike structures *r2* nearly round, larger than *r1*, close together just above anus. Setae number is one greater than in other anoetids, generally equal in length, and differing in position from *H. julorum* as follows: *vm1* anterioriad of *r1*, *vo1* laterad of *r2*, *vo3* close to posterior end of anus, *do7* ventral instead of dorsal. Correspondence of ventral setae to setae of other forms is made on the basis of relative position; the extra seta *vo-x* is then assumed to be the one posterioriad to *r2*. An anal plate is faintly visible. *Dorsum*. — Smooth except for finely granular rostrum. Propodosomal seta *dp1*, *dp2*, and *dp3* one-half or less length of typical metapodosomal setae; *dp4* slightly more separated than *dp3*, two-thirds length of typical metapodosomal setae; all metapodosomal setae approximately equal except for the unusual large, brush-like setae *dm1*, *do1*, and *do5*; bases of setae *dm1* are contiguous. Bursa copulatrix terminal with opening posteriorly. *Legs*. — All legs generally longer than *H. julorum*; tarsi especially longer. Setae number and arrangement typical, differing from *H. julorum* as follows: leg I seta *t* shorter, *f* finer, *ti2* longer, *ta1* larger, *ta15* long, tapering, almost equal to *ta16*; base of *ta2* separated from *ta1*, leg II seta *t* shorter, *f* finer, *ti2* with rounded end; leg III seta *t* shorter. Membranous claw base legs II-IV distinctly expanded and tapering.

*Male*. — (Plate 63). Length 0.240 mm.; width 0.140 mm. *Venter*. — Gnathosoma as in female. Ringlike structures *r1* nearly round, close together anterioriad of genitalia; *r2* oval, more separated than *r1*, anterior-laterad of genitalia. Setae hairlike, approximately two-thirds length of tibia II except *vm3* which is equal to tibia II, and setae presumed to be *vo1* and *vo2* shorter. Relative position of setae as in *H. julorum* except for more anteriorly placed opisthosomatic setae, *do4* ventral instead of dorsal and *do6* marginal. Setae *vo1* and *vo2* are observed with some uncertainty along with two pairs of tiny genital spicules, closely associated with the genitalia. Penial seta apparently normally directed anteriorly. Anus and external genitalia surrounded by faint genital plate. Two faint atypical sclerotized patches posterioriad of *r1*. If the above assumptions are correct relative to identity of setae, the male has the typical number of setae. *Dorsum*. — Smooth except for very faintly granular dorsum. Setae approximately two-thirds length of tibia II, except for *dp1*, *dp2*,

and *dp3* which are shorter. Setae *dp4* only slightly more separated than *dp3*. *Legs*. — Legs long and slender with especially long tarsi including legs I-II which in most male anoetids are shorter and more massive than legs III-IV. Setae similar in position to *H. julorum*, generally smaller with following differences: leg I *ti2* larger, and is striated as macro-sense organ *ta1*; *ta1* and *ta2* arise independently slightly distal to the tibio-tarsal joint; mid-tarsal setae more separated, *ta15* longer than *ta16*, and straight with rounded end; leg II *ti2* with rounded end and striated, *ta1* larger, mid-tarsal setae more separated. Membranous claw base legs II-IV as in female.

*Deutonymph*. — (Plate 62). Length 0.150 mm.; width 0.115 mm. *Venter*. — Fused pedipalps equal to tibia II; pedipalpal seta *pp1* nearly twice as long as fused pedipalps; sternum *st1*, and apodemata *a2* and *a3* continuous posteriorly with *a4* which latter are united in midline; membranous portion of *a4* faintly continuous in midline; *st2* Y-shaped anteriorly, posteriorly continuous with *st3*; *st4* short. Coxa I-III with extremely minute setae or possibly vestigial discs and are seen with difficulty; coxa IV with hairlike seta *vm1* mesiad of small sclerotized structure reminiscent of vestigial disc. Suctorial plate hexagonal, with two functional suckers *su*, two large central discs, and four relatively large setae posteriorly. *Dorsum*. — Propodosoma smooth and short with membranous anterior extension covering gnathosomal base and part of femurs I-II; hysterosoma distinctly longitudinally sculptured. Seta *dp4* nearly twice as long as *dp3* and slightly longer than hysterosomal setae; hysterosomal setae hairlike, nearly equal. Posterior opisthosoma tucked under to place seta *do4* in a ventral position. *Legs*. — Tarsi I-II and tibia and tarsus IV conspicuously shortened; arrangement of setae similar to *H. julorum*, with following differences: setae of leg I femur and genu longer and finer, especially *g3* which is longer than *pp1*; tibia setae more hairlike, *ta3* twice length of *pp1*, *ta5* longer than *pp1*, *ta16* small, spoon-shaped; leg II femur and genu setae longer and finer except for *g3*, *ti2* longer than *pp1*, *ta16* small lancet-shaped; leg III similar except for shorter *ta16*; leg IV *ti3* longer, *ta7* shorter; tarsus with long tapering terminal seta, claws I-III cleft.

*Remarks*. — Features useful in identifying this species for the adult are: conspicuous membranous structures associated with pedipalp, *pp2* arising nearly from center of pedipalp, smooth except for finely granular rostrum, membranous claw base expanded and tapering above claw, propodosomal setae *dp4* slightly longer and only slightly more separated than *dp3*; for the female, inverted V-shaped genitalia, terminal bursa copulatrix, more mesially placed ringlike structures *r1*, *r2* close together above anus, extra ventral opisthosomatic setae close to anus, peculiar brush-end setae *dm1*, *do1*, and *do5*, long tapering tarsus I seta *ta15*; for the male, ringlike structures above genitalia, opisthosomatic setae associa-

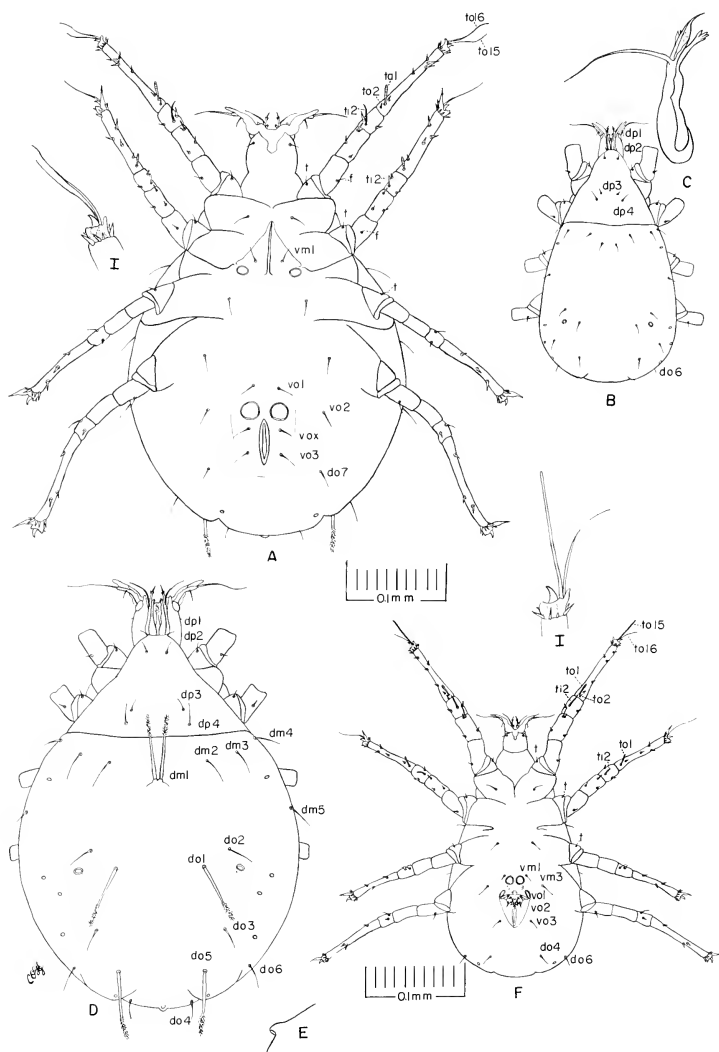


Plate 63 — *Myianoetus undulatus* sp. nov. A — female, venter. B — male, dorsum. C — chelicera. D — female, dorsum. E — bursa copulatrix. F — male, venter.



ted with genitalia difficult to observe, dorsal setae short hairlike, tarsus seta *ta15* leg I straight with rounded end, longer than *ta16*, *ti2* leg I-II atypically striated, similar to macro-sense organ *ta1*; for the deutonymph, arrangement of apodemata, extremely small setae or discs on coxa I and III, suctorial plate with two functional suckers *su*, two large central discs, and four strong posterior setae; unique crenulated dorsal hysterosoma; short tarsi I-II and tibia and tarsus IV, unusually long setae *ta3* and *ta5* leg I and *ti2* leg II, claws I-III cleft, leg IV with long tapering terminal seta probably representing a modified claw. Name chosen because of wave-like appearance of the dorsal hysterosoma of the deutonymph.

*Collections.* — Collected by R. D. Hughes in Chickahominy Swamp, near Ellerson, Virginia, August, 1953.

*Types.* — Holotype and paratypes in U. S. National Museum, Washington, D. C. Paratypes in authors' collection.

*Myianoetus diadematus* Willmann, 1937

(Plate 64)

*Female.* — (Plate 64). Length 0.500 mm.; width 0.270 mm. *Venter.* — Entire venter similar to *M. undulatus* including gnathosomal structure, setae, and position of ringlike structures. Differences as follows: anterior ringlike structures *r1* slightly larger and more separated, *r2* slightly smaller. Willmann's figure shows an extra seta near the posterior end of the longitudinal genital structure, which is presumed to be an error since thickenings of chitin have been observed in this area on *M. undulatus*. Also Willmann shows an extra seta *vo-x* laterad of anus which corresponds to *vo-x* in *M. undulatus*. *Dorsum.* — Smooth with conspicuous posterior boss-like structures. Except for *do4* which is ventral, setae similar in position to *M. undulatus* but shorter and spine-like. *Legs.* — All legs long and slender; tarsi especially long; leg I similar to *M. undulatus* except for shorter *ta15*; other legs similar. Willmann does not mention an expanded claw base. This may have been present and overlooked.

*Male.* — (Plate 64). Length 0.450 mm.; width 0.240 mm. *Venter.* — Gnathosoma as in female; setae similar in arrangement to *M. undulatus* but generally more spine-like; ringlike structures similar in position and somewhat smaller; genitalia similar. *Dorsum.* — Very similar to the female. *Legs.* — All legs long and slender as in *M. undulatus*, apparently setae similar in position; *ta15* not shown as being longer than *ta16*.

*Deutonymph.* — (Plate 64). Length 0.168 mm.; width 0.125 mm. *Venter.* — Fused pedipalps equal in length to genu II; pedipalpal seta *pp1* twice length of fused pedipalps; *pp2* less than one-third length of

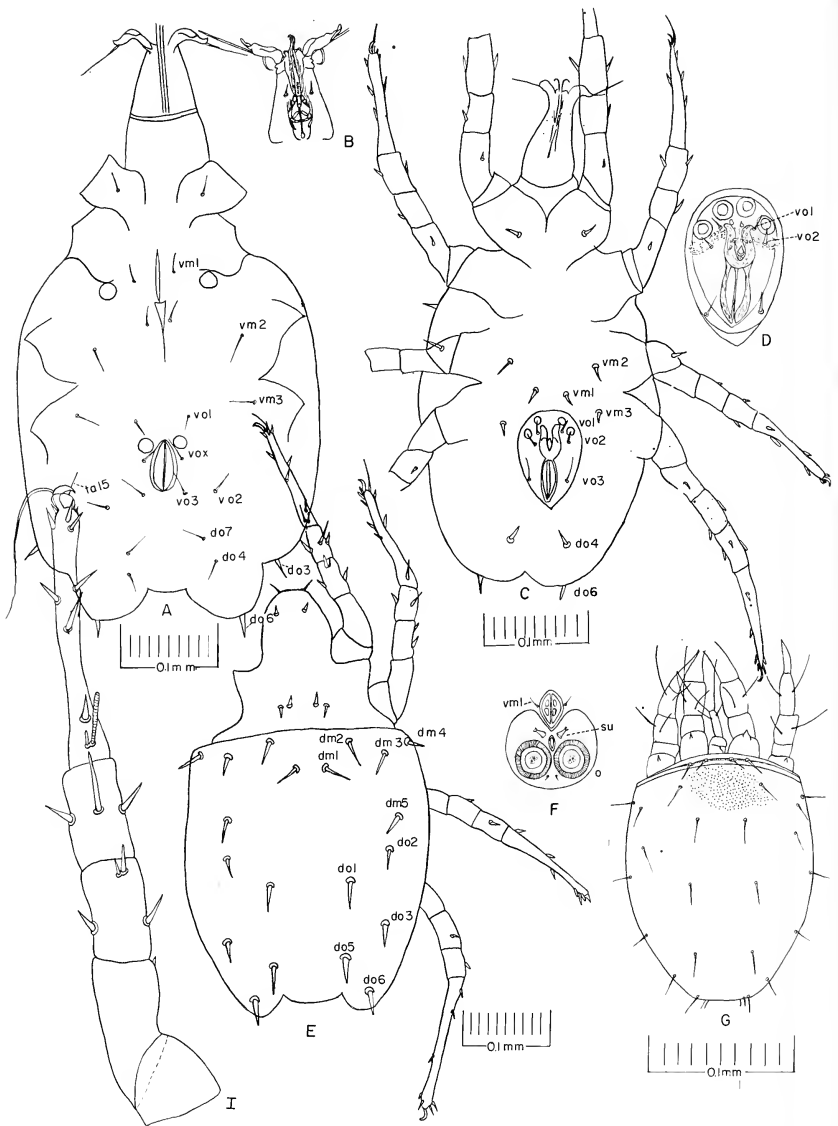


Plate 64 — *Myianoetus diadematus*. A — female, venter. B — gnathosoma. C — male, venter. D — male, genital plate. Lower left — female leg I. E — female, dorsum. F — deutonymph, suctorial plate. G — deutonymph, dorsum. (After Willmann)

*pp1*. Arrangement of apodemata apparently similar to *M. muscarum* and *M. digitiferous*; suctorial plate with two small suckers *su* and two large discs. Coxa IV with distinct hairlike seta *vm1*. *Dorsum*. — Propodosoma short; hysterosoma coarsely granular; setae hairlike, nearly equal to genu II, although somewhat variable in length. An extra seta is illustrated on Willmann's drawing as compared with *M. undulatus*. This is probably in error. *Legs*. — Willmann's only comment was that leg IV also has a long terminal seta.

*Remarks*. — This species is strikingly similar to *M. undulatus* with the following exceptions: for the adult, dorsal setae spine-like, *ta15* leg I shorter; for the female, seta *do4* in a ventral position, ringlike structures *r1* larger, *r2* smaller; for the male, ringlike structures smaller, ventral setae more spine-like; for the deutonymph, propodosoma shorter, hysterosoma heavily granular. This species was so named because of the fancied similarity of the propodosoma to a diadem. It should be recognized that the length of the propodosoma varies within the same species according to how specimens are mounted on the slide. Willmann was uncertain whether the adults described were *Myianoetus* sp. or *Histiostoma* sp. In view of the striking similarities between this species and other *Myianoetus* sp. for both the adult and deutonymph forms, it is certain that Willmann has correctly associated the adults and deutonymph in this instance. This observation is further supported by the fact that both the adults and deutonymphs were found in the same niche.

*Collections*. — Collected by C. Willmann from Segeberger Cave (deutonymph attached to cave insects) Holstein, Germany, 1935.

*Types*. — No record.

*Myianoetus filicum* (Dujardin), 1849

(Plate 65)

*Hypopus filicum* Dujardin, 1849; *Myianoetus filicum* (Dujardin), 1849 [Oudemans, 1937].

*Female*. — No information.

*Male*. — No information.

*Deutonymph*. — (Plate 65). Length 0.165 mm.; width 0.112 mm. *Venter*. — Fused pedipalps one-half length of tarsus II; pedipalpal seta *pp1* equal length of fused pedipalps; anterior portion of propodosoma extended well beyond gnathosomal base. Sternum *st1*, apodemata *a2* and *a3* continuous with apodemata *a4* which latter are united in midline; *st2* united with *a4* and *st1* anteriorly and apodemata *a5* posteriorly;

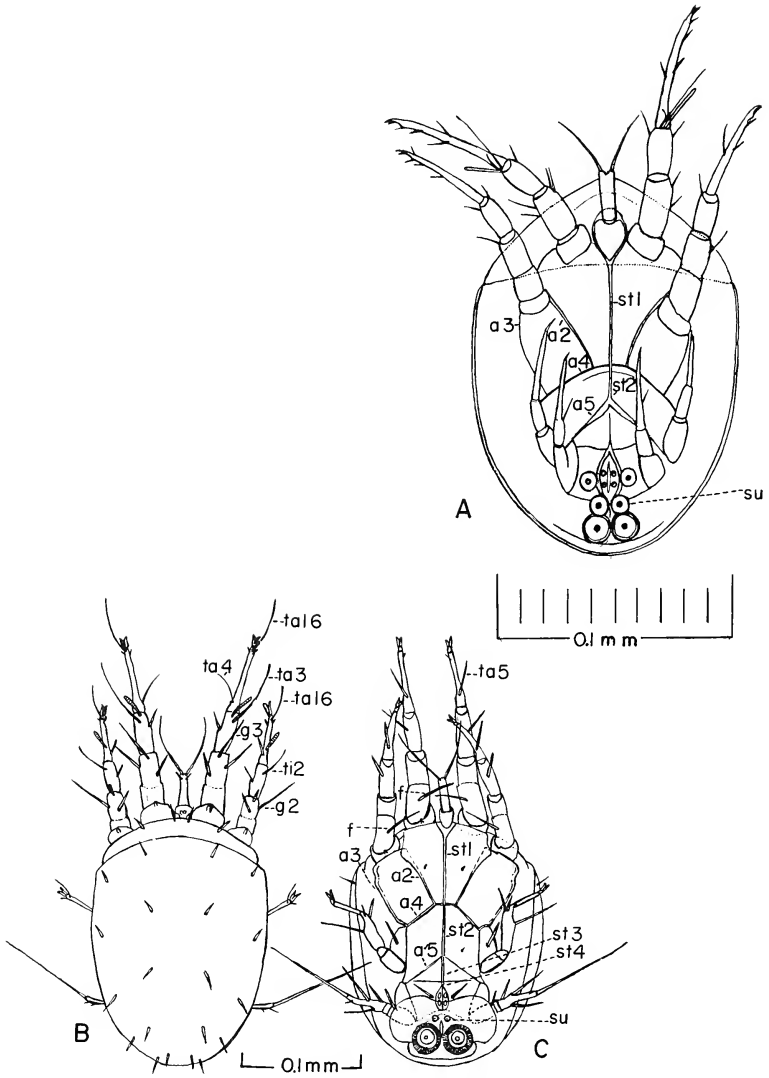


Plate 65 — Upper, *Myianoetus filicum* deutonymph. A — venter. (After Dujardin) Lower, *Myianoetus setipes* deutonymph. B — dorsum. C — venter. (Original unpublished drawing by A. C. Oudemans)

*a5* joined in midline. Coxae I and III apparently without discs or setae; coxa IV with disc equal to functional sucker *su* of suctorial plate. Suctorial plate with two functional suckers, and two large discs. *Dorsum*. — No information. *Legs*. — Legs I-II long and slender, tarsi I-II nearly twice as long as *M. undulatus*; legs III-IV considerably shorter and finer than I-II, setae arrangement probably similar to *M. undulatus*; claws I-III cleft.

*Remarks*. — The combination of characteristics placing this species in the genus *Myianoetus* are cleft claws legs I-III, arrangement of apodemata, and presence of two functional suckers and two large discs on suctorial plate. The well formed discs on coxa IV have not been observed in other *Myianoetus* species. In 1924c Oudemans erroneously identified *Hypopus filicum* as *H. sapromyzarum*. In 1937 he renamed this species *Myianoetus filicum*.

*Collections*. — Collected by Dujardin on fern *Ceterach officinarum*, September, 1848.

*Types*. — No record.

*Myianoetus muscarum* (Linnaeus), 1758

(Plates 66, 67)

*Acarus muscarum* Linnaeus, 1758 [deGeer, 1735]; *Pediculus muscae* (Linnaeus), 1758 [Gronovius, 1760]; *Trombidium muscarum* (Linnaeus), 1758 [Muller, 1776]; *Hypopus muscarum* (Linnaeus), 1758 [Duges, 1834]; *Tyroglyphus muscarum* (Linnaeus), 1758 [Gervais, 1844]; *Gamasus muscorum* (Linnaeus), 1758, [Fabricius, 1822]; *Anoetus muscarum* (Linnaeus), 1758 [Oudemans, 1929]; *Histiostoma muscarum* (Linnaeus), 1758 [Berlese, 1881]; *Myianoetus muscarum* (Linnaeus), 1758 [Oudemans, 1929].

*Female*. — (Plate 66). Length 0.485 mm.; width 0.250 mm. *Venter*. — Chelicera with three equal teeth; distinct membranous structures associated with pedipalp; pedipalpal seta *pp1* equal to tibia I, three times length of *pp2*. Apodemata *a1* not continuous in midline to form sternum. Ringlike structures *r1* similar in position, slightly larger than *M. undulatus*; *r2* contiguous with antero-lateral portion of anus. Transverse genital slit supported by distinct longitudinal structure mistaken for genital slit by Cooreman (1947). Propodosomal seta *vp1* equal to tibia II; other ventral setae somewhat shorter, slightly variable in length. Comparison of ventral setae with *M. undulatus* is as follows: *vml* postero-mesial of *r1*, *vol* more anterior, *vo2* contiguous with lateral border of *r2*, an extra seta *vo-x*, typical for this genus posterior to *r2*; *vo3* very close to posterior margin of anus, *do7* lateral and closer to

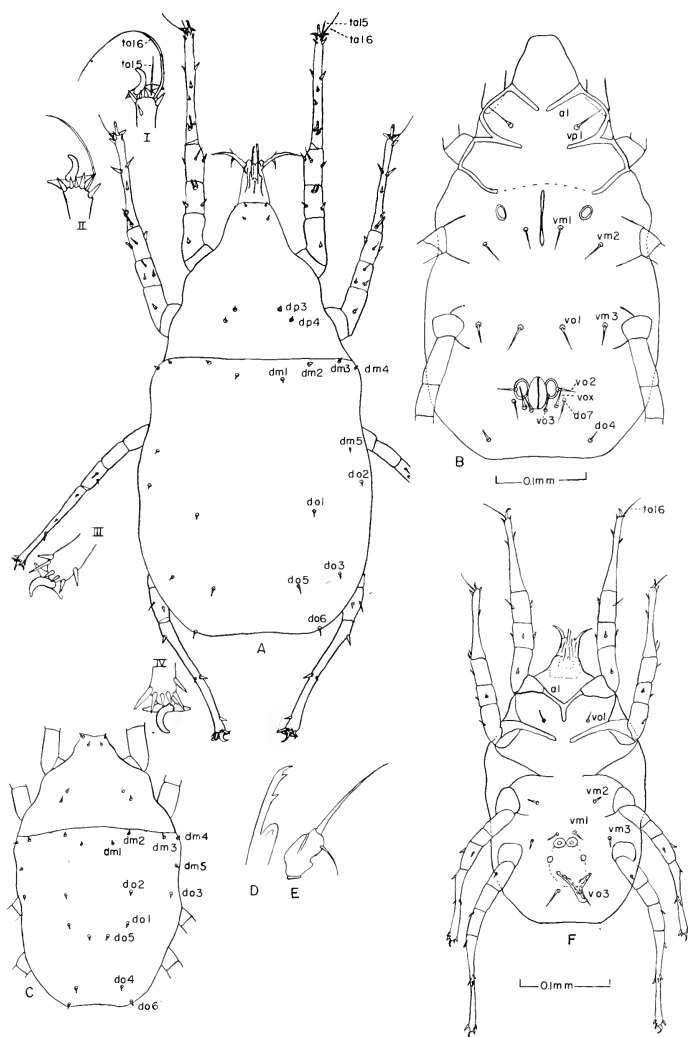


Plate 66 — *Myianoetus muscarum*. A — female, dorsum. Left — distal tarsi I-IV. B — female, venter. C — male, dorsum. D — chelicera. E — pedipalp. F — male, dorsum. (After Cooreman, except chelicera and pedipalp after Berlese)

posterior end of anus, *do4* ventral in position. *Dorsum*. — Dorsum with scattered pores and elevated surfaces which are more evident in living specimens (not shown in figure). All setae short and very fine, equal in length, difficult to observe; seta *do4* ventral. Excretory pores, pit-like structures, and bursa copulatrix neither described, or shown by Cooreman. *Legs*. — In comparison with *M. undulatus*, length and slenderness of legs similar; except omission of setae *t* legs I-III and seta *f* leg IV, setae size and arrangement differing only slightly from *M. undulatus*; *ta15* leg I less than one-half length of *ta16*. Claws slightly larger than *M. undulatus* and with expanded membranous claw bases.

*Male*. — (Plate 66). Length 0.300 mm.; width 0.180 mm. *Venter*. — Gnathosoma as in female. Apodemata *a1* continuous in midline forming a short sternum. Ringlike structures *r1* close together above external genitalia; *r1* laterad to posterior portion of genitalia. Comparison of setae with *M. undulatus* as follows: *vm2*, *vm3* shorter, *vo1*, *vo2* not observed, *vo3* longer. *Dorsum*. — Setae minute, equal, and difficult to observe, arrangement varying slightly from *M. undulatus*. No pit-like structures or excretory pores illustrated or described. *Legs*. — Shape similar to *M. undulatus*; *ta15* not longer than *ta16* leg I, no expanded claw bases shown in figure.

*Deutonymph*. — (Plate 67). Length 0.245 mm.; width 0.165 mm. *Venter*. — Fused pedipalps equal to tibia II; pedipalpal seta *pp1* over twice length of fused pedipalps; *pp2* less than one-half length of genu I. Apodemata *a2* divided posteriorly, with median portion joining base of *st1*, and with lateral portion free, *a4* continuous in midline; *st2* free anteriorly, posteriorly united with *a5* and *st3*; *st3* faintly joined to *st4*. Coxae I-III without discs or setae; coxa IV with hairlike seta, without disc. Suctorial plate with two functional suckers *su* and 2 large discs; a pair of faint structures posterior to plate discs resemble setae, but lie below surface. *Dorsum*. — Propodosoma smooth, very short; anterior membranous portion extends anteriorly to partially cover gnathosomal base and trochanters I-II; hysterosoma pitted and finely granular. Propodosomal setae spine-like, one-half length of genu I, nearly equal. Hysterosomal setae short, extremely fine and equal. *Legs*. — Leg shape and proportions of joints similar to *M. undulatus* except for relatively longer tarsus IV; setae generally similar, differences as follows: leg I setae *g3*, *ti1* shorter, *ta2* shorter and displaced to middle of tibia, *ta3* close to *ta2*, *ta5* much shorter, *ta16* long and tapering; leg II *g2* much longer, *ti1* shorter, *ti2* shorter, *ta16* long and tapering; leg III seta shorter; leg IV *ta4* shorter, terminal tarsal seta over twice as long as tibia and tarsus. Claws I-III characteristic for genus.

*Remarks*. — The combination of adult characteristics useful in identifying this species is as follows: chelicera with three equal teeth, con-

spicuous membranous structure associated with pedipalp, short fine dorsal setae, long slender legs, leg I seta *tal5* shorter than *tal6*; for the female, position of ringlike structures *r1* and *r2*, position of opisthosomatic setae *do4* and *do7* ventral instead of dorsal, presence of *vo-x*, dorsum with scattered pores, expanded membranous claw bases; for the male, short sternum, and ringlike structures above anus; for the deutonymph, long *pp1*, *pp2* arising nearly from center of fused pedipalps, arrangement of apodemata, no discs or setae on coxa I and III, coxa IV with seta and without disc, *tal6* legs I-II tapering distally, leg I *ta3* extremely long and displaced to center of tibia, leg II *g2* very long; leg IV with long tarsal seta, which is probably a modified claw. Linnaeus in 1758 adopted de Geer's description (1735) of this deutonymph and called it *Acarus muscarum*, the specific name after the stable fly *Musca stabulans*. Oudemans in 1929 placed this species in the newly erected genus *Myianoetus*. The adult was first described by Berlese in 1881. Cooreman's adult figures are used; deutonymph figures are from specimens supplied to present authors by W. W. Judd.

*Collections.* — Collected by de Geer on housefly, Paris, 1735; by Goeze on *Musca fenestralis*, Germany, 1779; by M. Dujardin on *Musca stabulans*, Paris, 1846; by Curtis on domestic fly, 1838; by A. Berlese on *Musca stabulans*, 1881, and on *Cyrtoneura stabulans*, 1886; by G. Canestrini on decaying material with *Cyrtoneura stabulans*, 1888; by Kramer and Canestrini on decayed vegetative material, Europe, 1899; by J. Cooreman on Diptera, 1947; by W. W. Sampson on houseflies, Berkeley, California, October, 1950; by M. T. James on *Calliphora terrae-novae*, Pullman, Washington, April, 1951; by B. Sugerman on *Synthesiomyia nudiseta*, San Juan, Puerto Rico, May, 1953; by W. W. Judd on *Muscina stabulans*, London and Ontario, Canada, June and September, 1953. From the references given by Oudemans (1937) it may be assumed that numerous additional collections were made prior to that date.

*Types.* — Holotype no record. Plesiotypes supplied by W. W. Judd in U. S. National Museum, Washington, D. C.

*Myianoetus setipes* (Koch), 1847, new combination

(Plate 65)

*Hypopus setipes* Koch, 1847; *Anoetus setipes* (Koch), 1847 [Oudemans, 1924c]; *Histiostoma digitifera* Tragardh, 1904; *Anoetus digitiferus* (Tragardh), 1904 [Oudemans, 1929]; *Myianoetus digitiferus* (Tragardh), 1904 [Oudemans, 1929]; *Anoetus dionychus* Oudemans, 1910; *Myianoetus dionychus* (Oudemans), 1910 [Oudemans, 1929].

*Female.* — No information.



*Male.* — No information.

*Deutonymph.* — (Plate 65). Length 0.220 mm.; width 0.150 mm. *Venter.* — Fused pedipalps equal to tibia II; pedipalpal seta *pp1* nearly twice length of fused pedipalps; *pp2* very short, close to distal end. Coxae I and III with minute setae; coxa IV with seta, without discs; suctorial plate with two functional suckers *su* and two large discs. Sterna *st1* and *st2* and apodemata *a2* and *a3* continuous with *a4*, which latter are united in midline; *st2* and *st3* continuous with united apodemata *a5*; *st3* and *st4* apparently joined. *Dorsum.* — Smooth. Propodosoma short, barely covering gnathosomal base and trochanters I-II. Setae spine-like and one-half length of tibia II, typical in arrangement. *Legs.* — Shape generally similar to *M. undulatus* except for longer tarsi

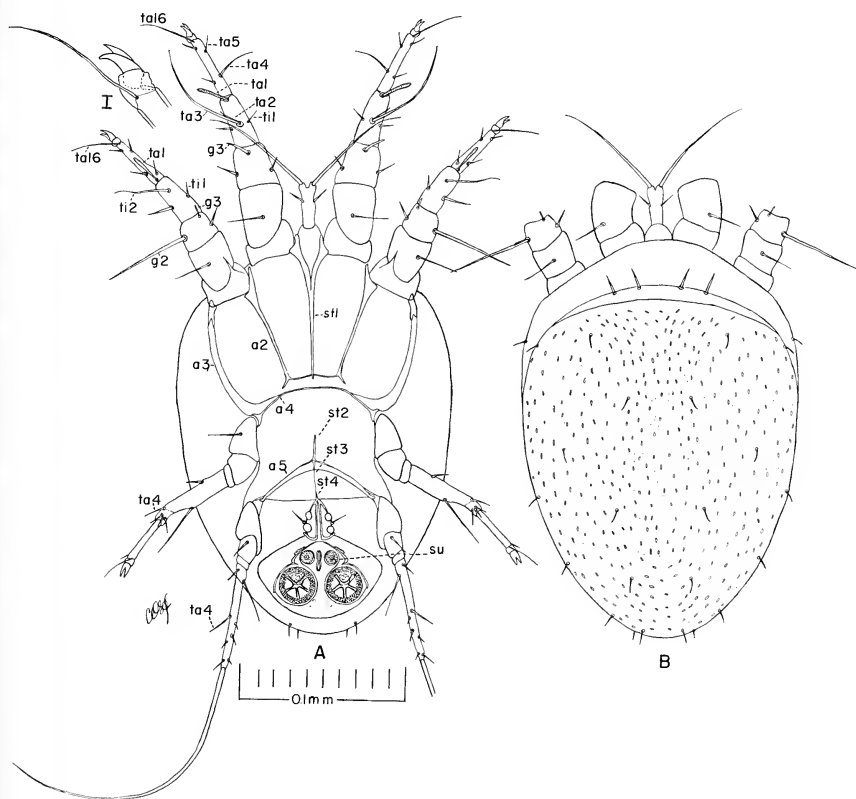


Plate 67 — *Myianoetus muscarum* deutonymph. A — venter. B — dorsum.

I-II; setae differences as follows: leg I seta *f* longer, *g3* shorter and equal to tibia I, *ta3* base slightly separated from *ta1* and equal to tarsus I, *ta4* longer, *ta5* shorter, *ta16* longer and tapering; Leg II seta *f* longer, *g2* longer, *ti2* shorter, two longer mid-tarsal setae, *ta16* long and tapering; proportion and setae arrangement very similar for legs III-IV. The full complement of leg setae is not shown in Oudemans' drawing.

*Remarks.* — Features most useful in identifying this species are as follows: size of soma, length of pedipalps, length and position of pedipalpal setae, arrangement of apodemata, minute coxa I and III setae, coxa IV without disc but with seta, smooth dorsum, spine-like dorsal setae, leg seta *ta3* equal in length to tarsus I, *g3* equal to tibia I; leg II *g2* equal to tibia I; *ta16* legs I-II long and tapering, terminal tarsal seta leg IV longer than entire leg. Tragardh shows three pairs of "suckers" on the suctorial plate. Also four spine-like processes are illustrated on the margin of the suctorial plate similar to those of *M. undulatus*. In 1929 Oudemans placed *A. digitiferus* (Tragardh), 1904 and *A. dionychus* Oudemans, 1910 in the newly created genus *Myianoetus*. In 1924c Oudemans erroneously identified *Hypopus setipes* Koch, 1847 as *Anoetus crenulatus* Oudemans 1909; in 1937 he corrected this error and synonymized *Hypopus setipes* with *Myianoetus digitiferus*.

*Collections.* — Collected by C. L. Koch on *Cryptoneura stabulans*, 1847; by W. Lunbeck on a fly, Orpiksuit, West Greenland, July, 1900; by S. J. Schmitz on *Plecotus auritus* L., 1910.

*Types.* — No record. Plesiotypes (*M. dionychus*) in Oudemans' collection.

#### GENUS *Prowichmannia* Radford, 1950

*Diagnosis of genus.* — Diagnosis is based on the deutonymph. Coxae I, III, and IV with discs. Suctorial plate with two functional suckers, and three pairs of oval discs equal in size, and smaller than suckers.

*Type.* — *Prowichmannia spiniferum* (Michael), 1901.

*Prowichmannia spiniferum* (Michael), 1901

(Plate 68)

*Histiostoma spiniferum* Michael, 1901; *Anoetus spiniferum* (Michael), 1901 [Oudemans, 1903b]; *Prowichmannia spiniferum* (Michael), 1901 [Radford, 1950]; *Wichmannia spiniferus* (Michael), 1901 [Oudemans, 1929].

*Female.* — (Plate 68). Length 0.260 mm.; width 0.100 mm. Venter.

— (No figure). Pedipalpal seta less than one-third length of tarsus I; *Dorsum*. — Granular, shape oblong. Rostrum clearly defined. Hysterosoma pointed posteriorly, four pairs of large setae borne on conspicuous elevations. The two pairs of anterior setae longer than hysterosoma; third pair one-third shorter; posterior pair nearly one-half again longer than hysterosoma. Propodosomal setae not shown. *Legs*. — Long and slender, proportion of joints, if accurate, unique for this anoetid; tarsi especially long. Typical complement of setae not shown.

*Male*. — Not observed.

*Deutonymph*. — (Plate 68). Length 0.200 mm.; width 0.120 mm. *Venter*. — Fused pedipalps longer than tibia I; pedipalpal seta *pp1* equal to genu I. Sternum *st1*, *st2*, and apodeme *a2* continuous with apodemata *a4* which latter are united in midline; *st2* separated at posterior end, united with apodemata *a5* and *st3*. Sterna *st3* and *st4* not united. Coxa I and III with discs smaller than coxa IV disc *di3*. Suctorial plate heart-shaped with two functional suckers *su* larger than the three pairs of equal, oval posterior discs. *Dorsum*. — Propodosoma smooth; hysterosoma granular. Setae minute, hairlike and equal. *Legs*. — Long and slender. Setae *ta16* legs I-IV tapering. Typical complement of leg setae not described or shown.

*Remarks*. — Features useful in identifying this species are as follows: for the female, *pp1* medium length, soma granular, long, and narrow, with four pairs of conspicuous elevations which bear setae; setae long and heavy, of varying lengths; for the deutonymph, length of fused pedipalps, seta *pp1* arrangement of apodemata, coxa I, III, and IV discs; heart-shaped suctorial plate, plate suckers and discs as for genus, granular hysterosoma, minute and equal dorsal setae, all legs with claws, and tapering setae *ta16*. Further details of the morphology of this species is necessary to correctly relate the genus *Prowichmannia* to other genera of the family Anoetidae. Oudemans' description of the deutonymph is used. Length of deutonymph according to him is 0.260 mm. It is not known whether he also observed the adult. Genus named in honor of J. E. Wichmann.

*Collections*. — Collected by S. A. Poppe in Vegesack, Germany, 1898. (Oudemans); by A. D. Michael in a mole's nest, England, 1901.

*Types*. — In Oudemans' collection.

#### GENUS *Sellea* Oudemans, 1929

*Diagnosis of genus*. — Diagnosis is based on deutonymph. Suctorial

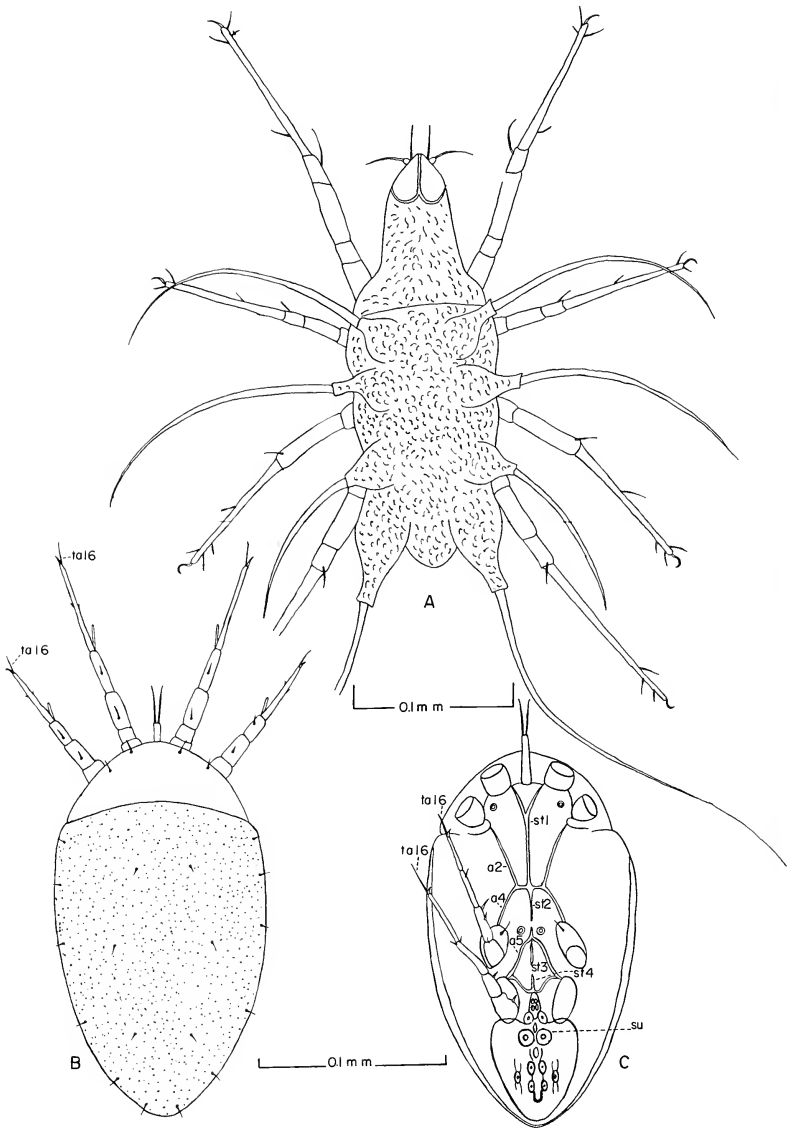


Plate 68 — *Prowichmannia spiniferum*. A — female, dorsum. B — deutonymph, dorsum. C — deutonymph, venter. (After Michael)

plate with two pairs of discs, one pair of suckers; suckers and discs of nearly equal size.

*Type.* — *Sellea pulchrum* (Kramer), 1886.

*Sellea pulchrum* (Kramer), 1886

(Plate 69)

*Histiostoma pulchrum* Kramer, 1886; *Sellea pulchrum* (Kramer), 1886 [Oudemans, 1929].

*Female.* — (Plate 69). Length 0.350 mm.; width 0.170 mm. *Venter.* — Chelicera hook-shaped distally, mesially with a series of fine teeth; pedipalpal seta *pp1* equal to tarsus II, twice length of *pp2*; a third pedipalpal seta proximal to *pp2* is illustrated by Michael probably in error. *Dorsum.* — Probably granular (not shown). Propodosomal setae not shown; hysterosomal setae of varying length as follows: *dm1* equal combined length of genu I and tibia I, *dm2* three times length of *dm1*; *dm3* and *dm4* nearly twice length of *dm1*, *dm5* very short and spine-like. Correspondence of opisthosomatic setae to other anoetids uncertain; anterior pair shorter than *dm1*, two postero-lateral pairs longer than *dm4*, posterior marginal pair nearly equal *dm2*; apparently two pairs of dorsal setae were not observed if the setae pattern of this species is typical. *Legs.* — Legs I-II somewhat heavier than III-IV; all claws sickle-shaped. Typical complement of leg setae neither shown nor described.

*Male.* — (Plate 69). Length 0.350 mm.; width 0.170 mm. *Venter.* — (No figure). Gnathosoma as in female. Apodemata *a1* joined to form short sternum; combined apodemata *a2-a3* close together in midline. Ringlike structures *r1* close together on anterior portion of coxa IV; *r2* more separated, opposite anus. Seta *vp1* on coxa III, *vm1* close to lateral margin of *r1*, *vm3* opposite genitalia, *vo1* and *vo2* opposite anus; penial seta posteriorly directed. *Dorsum.* — Probably granular (not shown). Rostrum sculptured according to Kramer. Propodosomal seta *dp3* shorter than *pp2*, *dp4* long, tapering. Hysterosoma with unique large, stiff, thick spines, mounted on conspicuous bosses, flattened ventrally and convex at proximal end, gradually becoming circular in form distally, with either sharp points or rounded ends. Three pairs of these unusual setae anteriorly, nearly one-half length of hysterosoma; four pairs of similar, but smaller setae posteriorly, with smallest mesially. Other hysterosomal setae typical, and *dm1* and *dm3* nearly one-half length of hysterosoma, *do1* much shorter, *do4* longer than hysterosoma. *Legs.* — Legs I-II stouter than III-IV. All claws long, strong and slightly curved. Terminal tarsal setae legs III-IV extended slightly beyond claw. The typical complement of leg setae is not shown or described.

*Deutonymph.* — (Plate 69). Length 0.165 mm.; width 0.105 mm.

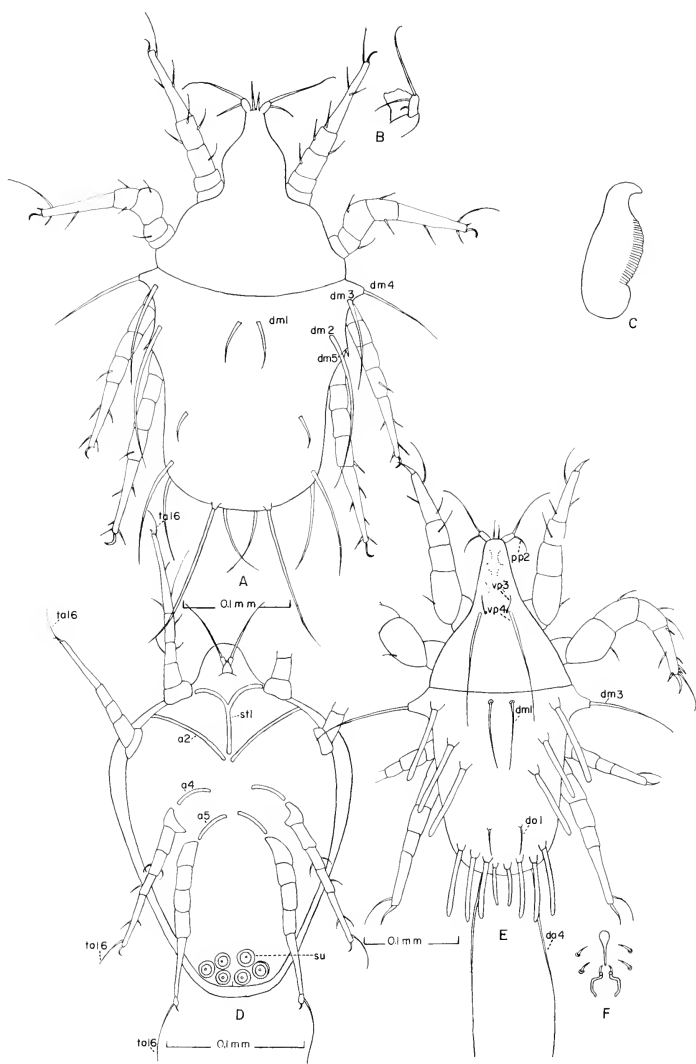


Plate 69 — *Sellea pulchrum*. A — female, dorsum. B — pedipalp. C — chelicera. D — deutonymph, venter. E — male, dorsum. F — male, external genitalia. (After Michael except composite drawing of male after Michael and Kramer)

*Venter*. — Fused pedipalps shorter than genu I, not extended or barely extended beyond gnathosomal base; pedipalpal seta *pp1* equal to tarsus II. Sternum *st1* and apodemata *a2* nearly joined in midline. Suctorial plate with three pairs of structures, the anterior pair of which is slightly larger, probably representing the functional suckers; two posterior discs equal in size. *Dorsum*. — Smooth, probably with minute setae. *Legs*. — Long and slender. Claws nearly straight. Seta *tal6* all legs tapering; seta *tal6* leg IV very long. Typical complement of leg setae not shown or described.

*Remarks*. — Features most useful in identifying the adults of this species are as follows: length of pedipalpal setae, and structures of chelicera; for the female, long tapering hysterosomal setae and sickle-shaped claws; for the male position of ringlike structures, arrangement of apodemata, unique large thick spines, and elongated typical spines on hysterosoma, claws long, strong and slightly curved, and terminal tarsal setae legs III-IV extended slightly beyond claws; for the deutonymph, short fused pedipalps, arrangement of apodemata, and arrangement of structures of suctorial plate, nearly straight claws, and tapering seta *tal6* all legs, with leg IV *tal6* especially long. This species is inadequately described by Michael and Kramer. Examination of specimens would be desirable to confirm the validity of this genus. Kramer maintained a colony of this species but described only the male. Genus named in honor of C. G. Selle.

*Collections*. — Collected by P. Kramer on sap of trees in Germany, 1886; by A. D. Michael on sap of trees in Warwickshire, England, 1901.

*Types*. — No record.

#### GENUS *Zwickia* Oudemans, 1924

*Diagnosis of genus*. — Diagnosis is based on the deutonymph. (Oudemans, 1929). Coxa I and III without discs or setae; coxa IV with seta laterad of disc *di3*. Suctorial plate with two functional suckers, two large central discs, and four discs laterally and posteriorly.

*Type*. — *Zwickia guentheri* (Oudemans), 1915.

*Remarks*. — The combination of characteristics considered diagnostic for a deutonymph of *Zwickia* have been observed only in *Z. guentheri*. Oudemans observed only one deutonymph specimen of this species, this partially destroyed by the enzymatic action of *Nepenthes* fluid. *A. nepenthesiana* and *A. gibsoni* deutonymphs and adults are strikingly similar in general appearance to *Z. guentheri*. Oudemans in 1924 considered absence of a suture between propodosoma and hysterosoma as diagnostic for

this genus. A suture in adult anoetids is often difficult to observe and hence, is an unreliable diagnostic feature. Genus named in honor of J. M. Zwicki.

*Zwickia guentheri* (Oudemans), 1915

(Plates 70, 71)

*Anoetus guentheri* Oudemans, 1915; *Zwickia guentheri* (Oudemans), 1915 [Oudemans, 1924].

*Female*. — (Plate 70). Length 0.450 mm.; width 0.285 mm. *Venter*. — Chelicera with wide base and with approximately fourteen teeth, curved and tapering distally. Pedipalp anteriorly directed; *pp1* anteriorly directed, nearly equal to genu I, twice length of laterally directed *pp2*. Ringlike structures large, nearly round; *r1* posterior to coxa II; *r2* on coxa IV. Anus close to posterior margin. Ventral setae hairlike, variable in length; *vp1* longer than tarsus I; *vm1* on line with *r1* near midline, nearly equal to genu I; *vm2* equal tarsus I; *vm3* equal tibia I, posterior to *r2*; opisthosomatic setae close to and opposite anus, equal to or shorter than genu I; *do7* ventral and marginal, equal to *vp1*. Small pit-like structures similar to those of *A. gibsoni* located mesiad and posteriad of vulva. *Dorsum*. — Smooth, without distinct suture between propodosoma and hysterosoma. Setae generally long, and fine; rostral setae and propodosomal setae nearly equal to tarsus II; hysterosomal setae variable, arranged in marginal or submarginal positions. Designations used for dorsal setae of other species are made on the basis of relative positions; *dm2*, *dm3*, and *do1* equal to tarsus I; other hysterosomal setae equal, nearly equal, or longer than tarsus II; *dm4* and *do7* shown as ventral in position; *dm1* not shown. Bursa copulatrix marginal. *Legs*. — Legs generally long and slender especially II-IV. Setae typical in number and arrangement except: *ta1* and *ta2* leg I and *ta1* leg II not shown, tarsus IV with extra seta; setae generally long and fine especially setae *f* legs I-II and leg IV, *t* leg III, and *ti2* leg I. Claw I long, slightly curved, claw II longer, claw III longer and nearly straight; claw IV indistinct in figure. Legs III-IV terminal tarsal setae very long, nearly equal to idiosoma.

*Male*. — (Plate 70). Length 0.320 mm.; width 0.165 mm. *Venter*. — Gnathosoma as in female. Sternum long, combined apodemata *a2* and *a3* united in midline, *a5* connected in midline. Ringlike structures nearly round; *r1* close together above genitalia, *r2* opposite anterior end of anus. Setae generally long, hairlike, variable in length, except *vm3* which is short and spine-like. Position of setae as follows: *vm1* antero-mesiad of *r1*, *vm2* antero-laterad of *r1*, *vm3* antierad of *r2*, *vo1* mesiad of *r2*, *vo2* opposite posterior end of anus, *vo3* posterio-laterad of anus. Penial seta



anteriorly directed and with two genital spicules. *Dorsum*. — Smooth, without distinct line of demarcation between propodosoma and hysterosoma. Setae long, hairlike, arrangement typical except: *dm4*, *do4* and *do5* on venter; medial setae generally shorter than marginal and submarginal setae. *Legs*. — Legs I-II considerably larger than III-IV. Setae number and arrangement typical, except: leg I seta *f*, either *g3* or *g4*, *ta2* missing, and leg II seta *t* missing; setae generally long, especially *f* legs II and IV, *t* leg III, and *ti2* legs I-II; *tal* legs I-II are shown as typical setae rather than as micro-sense organs. Claw I heavy, typical of most male anoetids; claw II exceptionally long, sickle-shaped; claws III-IV cannot be identified with certainty. Legs III-IV terminal tarsal setae longer than idiosoma.

*Deutonymph*. — (Plate 71). Length 0.225 mm.; width 0.145 mm. *Venter*. — Length of fused pedipalps equal to width, not extended beyond gnathosomal base; pedipalpal seta *pp1* nearly twice length of tarsus II. Sternum *st1* free posteriorly; apodemata *a2* curved toward midline and continuous with *a4*; *a4* not united in midline; *st3* and *st4* united. Coxae I and III without discs or setae; coxa IV seta *vm1* laterad of small discs *di3*; suctorial plate relatively small; functional suckers *su* and four posterior discs equal to coxa IV disc; central discs twice as large. *Dorsum*. — Sculptured (not shown in figure). Setae fine, minute, and equal. Propodosomal setae nearly marginal. Typical complement of dorsal setae not shown. *Legs*. — Legs I-II longer than III-IV especially tarsi. Setae arrangement typical except for several missing leg IV and missing *g3* leg II. Leg I seta *ta3* longer than tarsus I, *tal* equal to *ta2*, setae *tal6* leaf-shaped distally; leg II *tal6* tapering; leg III terminal tarsal seta equal to tibio-tarsus III; leg IV terminal tarsal seta nearly as long as hysterosoma. It is not known whether or not claws III-IV are missing, reduced or represented by long terminal tarsal setae.

*Remarks*. — Features useful in identifying the adult of this species are: anteriorly directed pedipalps, generally short pedipalpal setae, position of ringlike structures, generally long dorsal setae, and extremely long terminal tarsal setae legs III-IV; for the female, long ventral setae except for genital and anal setae, and unique medial setae except *vm3*; for the deutonymph short fused pedipalps, long setae *pp1*, arrangement of apodemata, small suctorial plate, minute dorsal setae, shape of *tal6* legs I-II, long terminal tarsal setae legs III-IV, as well as features diagnostic for genus. Worthy of note is the habitat of this species in common with a morphologically similar species *A. nepenthesiana* from the pitchers of *Nepenthes* sp. Numerous small animals have been observed as victims of the digestive enzymes of *Nepenthes* pitchers, among them the oribatid mites. Forms such as Diptera larvae were observed with mites as early as 1910 (Jensen) apparently not disintegrated by the digestive enzymes. Comparison of this species should also be made with another

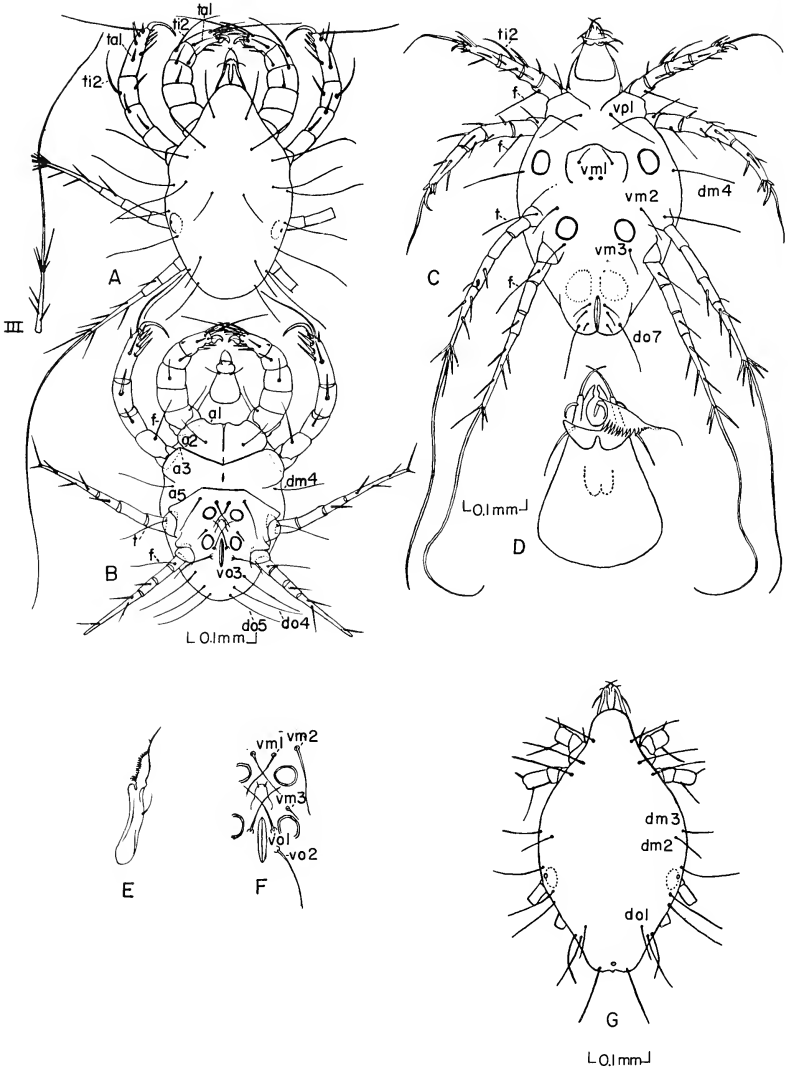


Plate 70 — *Zwickia guentheri*. A — male, dorsum. B — male, venter. C — female, venter. D — gnathosoma. E — chelicera. F — male, external genitalia. G — female, dorsum. (From Vitzthum after Oudemans)

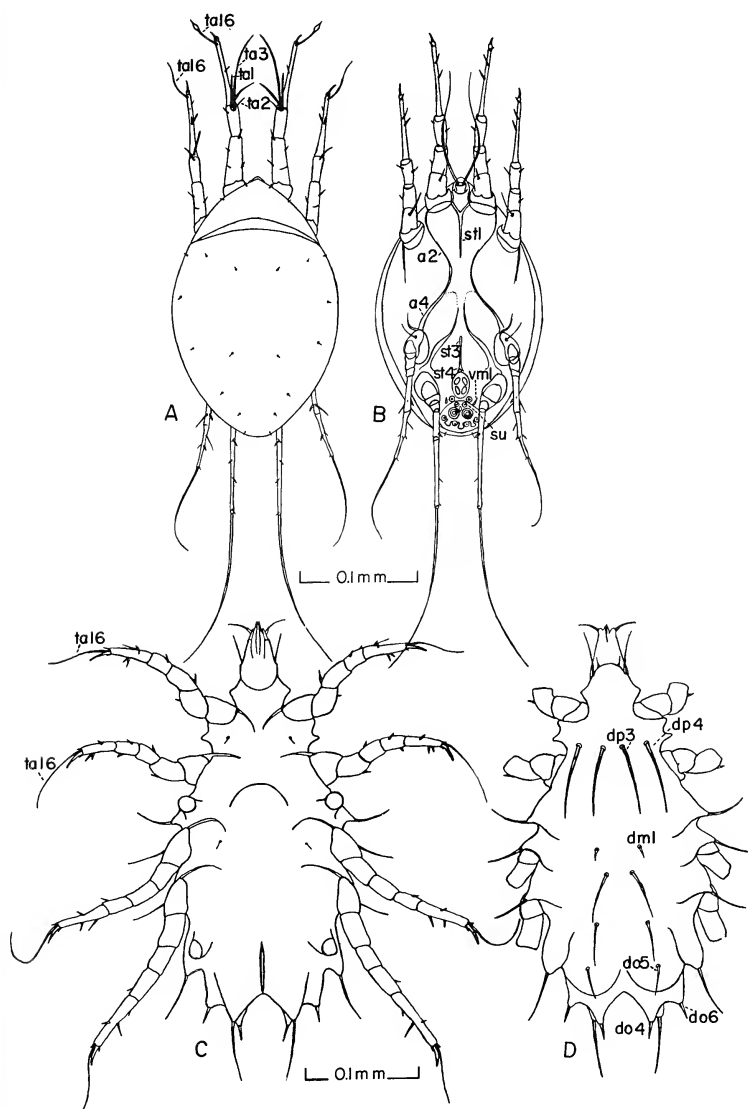


Plate 71 — Upper, *Zwickia guentheri* deutonymph. A — dorsum. B — venter. (From Vitzthum after Oudemans) Lower, *Zwickia colosiae* female. C — venter. D — dorsum. (After Vitzthum)

morphologically similar species *A. gibsoni* collected from the pitchers of *Sarracenia purpurea* L. by Nesbitt. Vitzthum claims the fluid from this plant is quite different from *Nepenthes* fluid. Nesbitt says the two fluids are similar, substantiating his statement by the fact that copepods of the same genus have been found in each. Other water dwelling forms of this family so far observed are *Z. colocasiae* from axil fluid of *Colocasia indica*, *H. cyrtandrae* from axil fluid of *Colocasia indica* and *Cyrtandra glabra*, and also in a goldfish tank, and *H. nigrellii* from a goldfish tank. Oudemans states that the normal position of adult legs III is anterior. Of the eighty-nine samples examined by him only one deutonymph was observed.

*Collections.* — Collected by K. Guenther in pitchers of *Nepenthes distillatoria* L., Ceylon, 1911; from *Nepenthes gymnamphora* pitchers in Sumatra and Java, before 1931.

*Types.* — No record.

*Zwickia colocasiae* (Vitzthum), 1931, new combination

(Plate 71)

*Anoetus colocasia* Vitzthum, 1931

*Female.* — (Plate 71). Length 0.320 mm.; width 0.165 mm. *Venter.* — Pedipalpal seta *pp1* equal length of genu I; *pp2* not illustrated by Vitzthum. Ringlike structures nearly round, borne on conspicuous elevations; *r2* posterior to coxa IV. Anus close to posterior end; posterior margin is conspicuously indented. Only coxa I and III setae shown. *Dorsum.* — Smooth with distinct nearly pointed marginal bosses, without distinct line of demarcation between propodosoma and hysterosoma. Setae generally long except very short *dm1*, short spine-like *do4* and *do6*, *do5* of medium length borne on rounded elevation, propodosomal setae *dp3* and *dp4* equal, longer than other setae. *Legs.* — Legs long and slender with relatively short tarsi I-II. Typical complement of leg setae not illustrated or described; terminal tarsal setae legs III-IV equal *ta16* legs I-II. Claws equal to tibia I, slightly curved.

*Male.* — (No figure). Length 0.245 mm.; width 0.128 mm. Similar in general appearance to female except for legs I, III, and IV which are nearly twice as thick as those of female, and with heavier sickle-shaped claws.

*Deutonymph.* — No information.

*Remarks.* — Features useful in identifying the female of this species are as follows: ventral ringlike structures borne on conspicuous eleva-

tions, dorsal setae generally long, propodosomal setae *dp3* and *dp4* longer and equal in length, distinct nearly pointed elevations marginally, all legs with long terminal tarsal setae, claws longer and less curved than typical for most anoetids. This species is insecurely placed in the genus *Zwickia* on the basis of the general appearance of the female. (Oudemans, 1924b).

*Collections.* — Collected by Vitzthum near the Sea of Ngebal in middle Java, before 1931 on leaf of Araceae *Colocasia indica*.

*Types.* — No record.

### *Nomina dubia*

A number of species in the literature presumably belonging to the family Anoetidae are so inadequately described that it would serve no useful purpose to record here the little information which is available. These are as follows:

*Bonomoia sphaerocerae* Vitzthum, 1922

\**Creutzeria tobaicae* Oudemans, 1932

\**Cederhjelmia quadriucinata* Oudemans, 1931

*Histiostoma brevipes* Banks, 1906

*Histiostoma flagellifer* (*flabelliforme*) Leonardi, 1897.

*Histiostoma genetica* Stolpe, 1938

\**Histiostoma phyllotrichus* (*trichophorus*) Berlese, 1883

*Histiostoma tarsalis* Banks, 1910

*Hypopus tarsispinus* Oudemans, 1910?

\**Myianoetus mixta* Oudemans, 1911

*Myianoetus tibetata* Vitzthum (no date) [Buitendijk, 1945]

*Nodopalpus ulmi* Karpelles, 1893

*Zschachia laevis* Oudemans, 1929

\*Specimens in Oudemans' collection [Buitendijk, 1945]

### DISCUSSION

*Morphology.* — The anoetids are minute organisms, the females

ranging in length from 0.770 mm. (*H. berghi*) to 0.250 mm. (*Glyphanoetus horridum*). Typically the males are about the size of tritonymphs of the same species, and range from a length of 0.390 mm. (*H. berghi*) to 0.167 mm. (*Glyphanoetus horridum*). In some species, however, the length of the male does not differ greatly from the female, e. g. *Sellea pulchrum*. There may be very considerable differences in the sizes of individuals of all stages in the same culture of the same species. (Plate 13.) These size ranges generally may be attributed to nutritional differences. Adult anoetids are nearly rectangular in outline, or pear-shaped, with no striking departures from this shape in any species. Except for the deutonymphs, the color of all stages of all species is whitish-opaque, the degree of opaqueness depending upon the amount of crystals or pseudocrystals contained in the body. The deutonymphs of the various species range in color from almost white to reddish brown.

There is remarkable uniformity in the leg and body setae number and general setae pattern in this family. All species studied from well preserved specimens by us conform to the number and pattern found in *H. julum*. Minor exceptions to this rule are: *Myianoetus* females with extra ventral seta *vo-x*; adults of *H. munchiei* leg II with supernumerary sensory tarsal seta *ta-x*; pedipalpal seta *pp2* in the adults either minute or missing, in the deutonymph *pp2* missing. *Anoetus gibsoni* male *pp2* either minute or missing.

In spite of the similarity of general appearance, and the uniformity of setae pattern and number, detailed studies reveal marked dissimilarities among species. Some of the features which are most often variable, and hence, useful in species determination are as follows for adults:

chelicerae — shape, number of teeth, etc.

pedipalps — lengths and relative lengths of *pp1* and *pp2*

ringlike structures — size, shape, position

sculpturing — presence or absence, type, degree. Sculpturing most often seen dorsally on rostrum

pitted dorsum — pitted, granular, or shagreened dorsum — presence or absence, type

protuberances — presence or absence, size, etc.

claws — shape, size, single or divided

body setae — shape, length, fineness, relative position

leg setae — shape, length, position

external genitalia — size, structure, with or without genital plate, especially male

bursa copulatrix — position, size, shape, direction of orifice

Deutonymphs: In addition to many of the characters above, the

type and arrangement of apodemata and details of suctorial plate are useful in identifying deutonymphs.

*Sexual dimorphism.* — Males differ from females in the following secondary sexual characteristics: generally smaller; in all males examined carefully, one less opisthosomatic seta (*do7*), (See p. 18); ringlike structures generally closer to genitalia; typically seta *ta15* leg I nearly claw-shaped; claws often somewhat more massive; other minor differences which are not typical for most species, such as serrated claws III-IV in male (*H. julorum*) and barbed seta *ta5* legs III-IV in female (*H. phyllophorus*); pilose dorsal setae in female (*H. piloseta*) and in deutonymph (*H. tienhoveni*); legs I-II tibial setae *ti2* appear to be sensory as tarsal I-II setae *ta1* (*Myianoetus undulatus*), terminal tarsal setae *ta9* legs III-IV longer in male than in female (*Anoetus gibsoni*).

*Life cycle.* — Only the life cycle of *H. julorum* has been examined carefully, although there have been many opportunities to observe the larval and nymphal stages of many species. It appears that with only one possible exception the stages of all species observed correspond to those of *H. julorum*, i. e. egg — larva — protonymph — deutonymph (this stage may be omitted) — tritonymph — adult. The possible exception is *H. murchiei* in which no tritonymphs have been observed. (See p. 93). It is interesting that some larvae of the same species and in the same culture metamorphose directly into the tritonymph stage, omitting the deutonymph. This phenomenon cannot be explained at present.

*Habitat.* — The anoetids have been reported from a wide variety of habitats. Two common features of the habitats of all trophic forms are abundance of organic matter usually in a state of putrefaction and abundant moisture. Most species which have been examined in the laboratory appear to be continuously feeding on the surface film of fluid containing yeasts and other microorganisms. *H. nigrellii* and *H. cyrtandrae* appear to thrive completely submerged and can be seen feeding among aquarium plants on debris. Nigrelli (1954) was led to believe that these two species gave off substances sufficiently toxic to kill fish. *H. cyrtandrae*, however, can be cultured readily on moist standard media (see p. 60). The only two species which are known to be parasitic are *H. murchiei* and *H. bergi* which destroy the eggs of earthworms and leeches respectively. (see p. 91 and p. 51). Yeast culture media used in *Drosophila* stocks are favorable media for many anoetids. Mites may accumulate in such large numbers that they become pests. In addition to competing for available food, the deutonymphs may attach to the mouth parts and genitalia of *Drosophila* in sufficient numbers to interfere with feeding and copulation. Although anoetids have been reported from many temperate and tropical parts of the world and in a variety of niches, it must be pointed out that we do not yet have adequate knowledge of the

possible habitats of tropic forms since the majority of species described are based on the non-feeding deutonymph which attaches itself readily to any passing insect and in this manner may effectively disperse a species over wide areas and away from original nutritional source.

*Chromosomes.* — Preliminary studies of the chromosome number for various species have been undertaken. These studies show that the chromosome numbers vary among the species and that the number is relatively small, *e. g.* *A. laboratorium*: haploid number — 4. The chromosome count is made on early cleavage divisions of the uterine egg. Such observations are not only useful in speciation problems but also to establish whether a given species is or is not arrhenotokous.

*Mode of reproduction.* — Approximately twenty species of anoetids have been cultured in our laboratory. Of this number four species reproduce by thelytoky, no males being produced. In some sixteen species both males and females are produced. Careful isolation studies of virgin females have not been made on all sixteen species. However, such studies were made on about ten species. In all except one of these ten species, unfertilized eggs developed parthenogenetically, giving rise to males only. Fertilized eggs gave rise to females only. Thus arrhenotoky is probably the mode of reproduction for most of the sixteen species referred to above, including *A. laboratorium*, as confirmed cytologically. In one species, *H. fimetarium*, prolonged attempts to obtain offspring from virgin females failed. Yet the sex ratio in this species was similar to a typical arrhenotokous species, *i. e.* the ratio of males to females was not 1:1 but highly variable. This suggests that the males are haploid as in the haplo-diploid parthenogenetic forms. It appears, however, that although the mode of reproduction and sex determination in *H. fimetarium* is probably the same as for typical arrhenotokous species, pseudofertilization or at least insemination is necessary to initiate development of male producing eggs. Tentatively it must be concluded that in some manner insemination is necessary to initiate development of eggs of this species.

Diploid parthenogenesis is not an uncommon mode of reproduction since it is found occasionally in many animal phyla. On the other hand, male parthenogenesis is of much rarer occurrence, it having been found in only five groups of animals. It appears to be common among the Acarina so far investigated and the predominant type of reproduction in the Hymenoptera. As White (1954) and others have pointed out, male and female parthenogenesis are entirely different modes of reproduction and could be expected to evolve separately over long periods of time as appears to be the case for Hymenoptera. It is of interest to note in this connection that in *H. humiditatis* and in an undescribed "variety" of this species in our collection and in *H. feroniarum* both thelytokous and ar-



rhentokous "varieties" occur in essentially the same habitat. The female of the thelytokous "variety" is virtually indistinguishable from the arrhenotokous "variety" in each of the two species. This would seem to indicate the extreme plasticity of modes of reproduction in the Anoetidae or that arrhenotoky and thelytoky are not unrelated modes of reproduction, at least in Anoetidae.

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## News and Notes

*(Editor's Note: News contributions should be sent to the person whose name appears at the end of the appropriate sections.)*

### THE PRESIDENT'S MESSAGE

The thirty-sixth annual meeting of the Virginia Academy of Science will be held at the Hotel Roanoke on May 7-10, 1958. It is indicative of the widening interests of our membership that this meeting will be sponsored by Hollins College, Roanoke College, Virginia Polytechnic Institute, American Viscose Corporation, Norfolk and Western Railway, and the Veterans Administration Hospital. The Local Arrangements for the meeting are being handled by a Committee drawn largely from these institutions and under the very capable chairmanship of Dr. Boyd Harshbarger. With full cooperation between this strong committee and the officers and members of the Academy, we are confident that these arrangements will be as satisfactorily complete as they can be made.

It goes without saying that a great deal of the value of the Annual Meeting depends upon the quality of the programs of the individual Sections; it is, therefore, a pleasure to acknowledge the able assistance of the officers of the several Sections in helping to insure the success of the Roanoke meeting. It is through these officers too, that the Academy invites entrants for the J. Shelton Horsley Research Award which is given each year for a "highly meritorious" paper presented at the May meeting.

This year of the Sputniks will be a particularly significant one for the future of science in our State as, on all sides, we see a quickened interest in the development of our scientific potential. How best to operate in this favorable clime in "encouraging scientific research" and sustaining "public interest in science" will be, as it should, a main concern for our whole Academy membership in the days immediately ahead.

It is with such ends in view that the members of the various Academy committees are continuing to work. For them, as for the Junior exhibitors and those who will be reporting the results of their scientific investigations, a banner attendance at Roanoke would provide the very finest encouragement.

W. G. GUY, *President*

## PAUL RANDOLPH BURCH

Professor Paul R. Burch, a member of the Radford College Faculty and the Chairman of the Biology Department from 1928-1953, died January 9, 1958.

Doctor Burch was deeply respected by his students and colleagues and a great loss was felt by them when he retired in 1953. His death on January 9th has magnified this loss. His contagious enthusiasm for meeting a challenge in science or other fields of endeavor, his intense participation in any cause he championed, his integrity, and common sense, combined to make Paul Burch a refreshing personality who gave enduring inspiration to his students and who will continue through them to inspire the lives of their students.

— Andrew L. Ingles, *Radford College*

## MINUTES OF THE COUNCIL MEETING

Longwood House, Farmville, Virginia

October 20, 1957

The meeting was called to order by President William G. Guy at 1:30 P.M. In addition to the council members, President Guy had invited section and committee chairmen to meet with the council. Members in attendance were: Lynn D. Abbott, Jr., Robert T. Brumfield, John C. Forbes, Irving G. Foster, Edward S. Harlow, Charles F. Lane, Paul M. Patterson, and Foley F. Smith.

The meeting was preceded by a luncheon where President Francis G. Lankford and Dr. George W. Jeffers represented the host institution, Longwood College. President Lankford welcomed the group. President Guy invited both to stay through the ensuing meeting, but Dr. Lankford was unable to do so.

Section chairmen present were: J. C. Holmes, *Chemistry*; Noble R. McEwen, *Psychology*; Vera B. Remsburg, *Science Teachers*; and Otis L. Updike, Jr., *Engineering*.

Committee Chairmen other than those on Council, R. A. Clayton, *Chairman, Membership Committee* and A. B. Massey, *Chairman, Virginia Flora Committee* also attended.

## SECTION REPORTS

Dr. Holmes reported that an objective for the coming year was to

strike a numerical balance between industrial and academic reports in the Chemistry Section.

Dr. Updike reported similar effort in the Engineering Section.

Dr. McEwen reported he was working for a balance in papers between academic and clinical psychology.

Mrs. Remsburg reported for the Science Teachers Section that the program for the Roanoke meeting was well in hand.

### COMMITTEE REPORTS

Dr. Massey reported on recent taxonomic publications in the state.

Dr. Clayton said there were some 860 members of ACS in Virginia not members of VAS and a solicitation of them is being made.

He further stated that the Academy is not well known in Northern Virginia, and he hopes to send information about VAS to about 1000 biologists, engineers and science teachers in that area.

President Guy reported that E. D. Crittenden, Chairman of the Education Committee regretted his inability to be present. In this connection the President stated that in conversation with Dr. Paschall, State Superintendent of Education, he had learned that it is the thinking in the State Department of Education that the requirements for teacher certification in science will be raised and that an advisory committee on education in scientific fields will soon be set up.

Dr. Abbott, reporting as Chairman of the Long Range Planning Committee, said a subcommittee had been organized to look into possible sources of funds for the Virginia Academy particularly for a proposed study of the results of the science talent searches.

Mrs. Heatwole reported by letter that the initial organization for the year had been made for the Junior Academy of Science. Funds for the Junior Science Bulletin and prizes are being requested again from the American Tobacco Company and the Philip Morris Company.

### OLD BUSINESS

#### SEASHORE STATE PARK

Following the instructions in the minutes of May 11, 1957, visits were made to the University of Virginia, Virginia Polytechnic Institute, and William and Mary. Edward Harlow reported that the University

of Virginia is not interested in participating in setting up a State Science Center in the Park. However, Virginia Polytechnic Institute and the College of William and Mary did indicate interest. President Chandler has promised to discuss the matter with the Council of Higher Education.

CONCERNING THE DISMAL SWAMP PROJECT, President Guy reported that J. T. Baldwin has not had time to work on this recently, but is interested, and will continue to pursue the project.

President Guy announced the appointment of two new committees: The Committee of Public Information. A formal committee was thought inadvisable but a group should be segregated to disseminate information for the press informally. The Council moved and passed that this matter be left to the President's discretion. Committee on the History of Science in Virginia. I. G. Foster has agreed to be Chairman of the Committee, and each section is requested to designate a member to cooperate with this Committee.

Auditing the treasurer's books by an Academy Committee was authorized as an experiment as was done last year. The question arose as to whether we should so continue or return to CPA auditing. Council passed a motion to have the books audited this year by CPA. If CPA auditing every other year for a two year period is cheaper than annual auditing the Council may entertain a constitutional change.

Robert Brumfield, Editor of the Journal, reported the Journal in good condition. The need for an advertising manager is acute at the moment. Ed Harlow reported one or two possible candidates. His main report centered about the mounting cost of publication and the sharp reduction in reserve funds. Additional funds for the Journal is becoming imperative. Charles Lane, as Managing Editor also reported briefly.

Robert Brumfield, Chairman of the Research Committee, gave a report on grants made so far and the balance of research funds. He thought rather few people knew about these funds, and their existence should be better advertised.

## NEW BUSINESS

A proposal that VAS investigate participation with the Engineering Societies of the Richmond area was proposed by letter by Henry Leidheiser, Jr. Instead of sending two Engineering Section representatives, as suggested, Council decided upon motion that the President appoint representatives as follows: One, Leidheiser, as a member of the Long Range Committee, and one member of the VAS Engineering Section resident in Richmond area for the purpose of examining their proposals



more carefully. It will be noticed that Council modified the request on representation.

Dr. Forbes presented a plan for stimulating research principally during summer vacations by scientists in the academic professions in Virginia, principally the younger teachers. There is first the question as to how widespread an interest in this exists and if so, how to accumulate funds for its implementation. Council passed a request that the President appoint a committee to survey the demand for such possible opportunity preliminary to an effort to raise funds. Various suggestions as to possible areas of available funds were made in case the need was found to be real.

The Secretary was instructed to send a message to Marcellus Stow regretting his absence due to illness and sending him the Council's sympathy.

Adjournment

— Paul M. Patterson, *Secretary*.

#### AGRICULTURAL SCIENCE SECTION

Tobacco disease research should get quite a boost from the new facilities now being constructed at the Tobacco Disease Research Station, Chatham, Virginia. These facilities consist of an office and laboratory building with a connecting greenhouse, a tobacco compartment curing barn, a combination shop and machinery storage shed, a tobacco stripping, grading and storage building and a small residence for the station foreman. The professional staff at the Chatham station includes Mr. J. L. LaPrade, Dr. Wirt H. Wills, and Dr. J. L. Troutman. The work at this station is administered through the Department of Plant Pathology and Physiology, Virginia Polytechnic Institute, Blacksburg.

Paul M. Reaves, a member of the Dairy Science staff at the Virginia Polytechnic Institute, received the first Wine Teaching Award in the School of Agriculture. Along with the award a check of \$500 was presented to Professor Reaves. Reaves joined the Dairy Staff in 1928 and teaches courses in dairy production.

Dr. W. A. Hardison, Department of Dairy Science, attended a Trace Mineral Symposium at Wooster, Ohio. He is at present conducting research on the copper requirements of dairy calves.

Mr. Harold W. Walker has been assigned as Assistant Agricultural Economist with the Extension Service at the Virginia Polytechnic Institute. Mr. Walker's work will be primarily in poultry marketing. He is a 1950 graduate of the Virginia Polytechnic Institute, and previously has been

engaged in farming and working with Rocco Feeds, Inc., Harrisonburg, Virginia.

Assistant Professor of Business Education, J. C. Hall, resigned his position in the Department of Vocational Education at the Virginia Polytechnic Institute on September 1, 1957, to accept a position as head of Business Education at the Alabama Polytechnic Institute. Mr. J. R. Stewart who completed his work for the Master's degree during the past summer has been appointed as Dr. Hall's successor.

Mrs. Lucy Crawford, who holds two degrees from Furman, assumed her duties as Associate Professor of Distributive Education on July 1, 1957, succeeding R. L. Almarode who resigned last April. Mrs. Crawford heads the recently organized program at the Virginia Polytechnic Institute for training teachers in the joint vocational fields of Distributive Education and Diversified Occupations.

Under the direction of Dr. J. S. Carpenter, Associate Professor of Trade and Industrial Education, progress is being made in organizing a curriculum for training trade and industrial teachers. Much of Dr. Carpenter's time during the past year has been devoted to off-campus classes for teachers of trade and industrial subjects in the schools at Wise, Abingdon, Roanoke, Fishersville, and Danville.

Dr. B. C. Bass, Associate Professor of Agricultural Education completed "A Study to Determine Units in the Area of Farm Management That Should Be Taught Students in Vocational Classes."

Dr. T. J. Horne, Professor and Head of Agricultural Education at the Virginia Polytechnic Institute, was one of three participants in a recently completed Southern Regional study entitled: "What Constitutes an Effective Program of Vocational Agriculture in a Community." Conclusions of the study were based on information secured from high school youth, young farmers, adult farmers, teachers of vocational agriculture, principals, and superintendents in the twelve Southern States. Dr. Horne is now serving as chairman of the National Research Committee in Agriculture Education.

—Carl W. Allen, *Virginia Polytechnic Institute*.

#### ASTRONOMY, MATHEMATICS, PHYSICS SECTION

Prof. J. G. Stipe has returned to the Physics staff at Randolph-Macon Woman's College after a year as a Carnegie Intern in General Education at Harvard University.

At the University of Virginia Drs. Berko, Plaskett, and Whitehead have been promoted to Associate Professorships. Dr. Berko has recently

received a Sloan Foundation Fellowship.

The Physics Department at the Virginia Polytechnic Institute has received a grant of \$159,700 from the AEC for the purchase of laboratory equipment in nuclear physics and engineering. Dr. Theodore E. Leinhardt, formerly with Sperry Gyroscope Company, has been appointed Associate Professor of Physics.

Dr. W. O. McMinn, recently at Clarkson College, and Dr. John McKnight, 1957 graduate of Yale University, have joined the Physics staff at William and Mary. Dr. Frederick O. Crownfield has been promoted to Associate Professor of Physics.

Dr. A. D. Campbell has been promoted to Associate Professor of Physics at the University of Richmond.

Dr. A. N. Vyssotsky, Professor of Astronomy at Leander McCormick Observatory of the University of Virginia, has been elected a vice-president of the American Astronomical Society.

Dr. E. R. Dyer, Jr., is on leave from McCormick Observatory serving as Assistant Professor of Astronomy at Georgetown University. Dr. Valfred Osvalds has been appointed acting Assistant Professor of Astronomy at McCormick Observatory.

—Irving G. Foster, *Virginia Military Institute*

### BACTERIOLOGY SECTION

Dr. Holmes T. Knighton, Medical College of Virginia, attended and participated in a seminar on wound healing, sponsored by the Rowe-Smith Foundation, from December 8 through 11, at Karnack, Texas.

Dr. E. Clifford Nelson attended the symposium on Animal Diseases and Human Health sponsored by the New York Academy of Science, September 11 through 13.

—P. Arne Hansen, *University of Maryland*

### BIOLOGY SECTION

Dr. H. G. M. Jopson of Bridgewater College and Dr. J. J. Murray, Jr., of Washington and Lee University, each spent a number of weeks at the Oregon Institute of Marine Biology, Charleston, Oregon, during the summer of 1957.

A new greenhouse has been acquired by the Hollins College Biology Department. The structure is a single span one with aluminum frame and redwood rafters.

Longwood College has added Dr. E. F. Stillwell, a recent graduate in physiology from Duke University, to its staff as an Assistant Professor. Robert E. Merritt of Longwood, presently on leave at the University of Tennessee, is replaced this year by Dr. Jacobus M. L. Lodewijks, an exchange teacher from the Netherlands. Dr. Lodewijks was the first president of the World Federation of Aquarists. Mr. Aaron O'Bier, who received his Master's degree from the University of Richmond is now working on the AEC project at Longwood under the direction of Dr. R. T. Brumfield.

At the University of Virginia Mr. Richard D. McKenney has been appointed Instructor in Biology. Mr. McKenney will complete a doctorate in Physiological Mycology at Stanford University in January. The National Science Foundation has awarded Drs. Samuel P. Maroney and J. N. Dent a grant of \$8,000.00 for the purchase of equipment to be used in research employing radioisotopes. Dr. Addison E. Lee from the Biology Faculty of the University of Texas is serving as Visiting Professor of Biology. Dr. Lee is primarily responsible for the Department's contribution to the NSF sponsored Academic Year Institute for High School Teachers being held at the University.

The twenty-eighth session of the Mountain Lake Biological Station proved to be a most successful one with 85 students and investigators working during the two terms. The professorial staff was composed of Dr. Robert T. Brumfield, Longwood College; Dr. A. C. Cole, University of Tennessee; Dr. Edward S. Deevey, Jr., Yale University; Dr. Gerhard Fankhauser, Princeton University; Dr. Thomas E. Kennerly, Baylor University; Dr. Samuel P. Maroney, Jr., University of Virginia; Dr. Gerald W. Prescott, Michigan State University; and Dr. Catherine M. Russell, University of Virginia Medical School. Phipps and Bird, Inc., presented a scholarship to one student, and the National Science Foundation provided funds for 12 Awards for students and investigators at the Station. The National Science Foundation has recently made available funds for the construction of three additional laboratories in the basement of the main building.

Dr. Willis G. Hewatt of Texas Christian University and Dr. Robert W. Ramsey of the Medical College of Virginia each taught important courses at the Virginia Fisheries Laboratory during the past summer. The *Pathfinder*, new research vessel of the Laboratory, was delivered in June, 1957, is now outfitted and in service and is proving a fine vessel for its purpose. The Fisheries Laboratory has construction well under way on a new combination laboratory-dormitory building which will considerably expand facilities for graduate students, summer assistants and visiting professors.

Among staff members of the Virginia Fisheries Laboratory — Dr.

Jay D. Andrews has been appointed Chairman of the Editorial Committee of the National Shellfisheries Association, and Dr. J. L. McHugh has been named Chairman of the Scientific Advisory Committee of the Atlantic States Marine Fisheries Commission and presided at the meetings of that group in New York in September 1957.

Important staff activities at the Virginia Polytechnic Institute include the following:

Professor J. D. Wilson retired as head of the Biology Department January 31, 1958. Professor Wilson served as head of the department for nearly 35 years. Ever active, Professor Wilson will spend the next two years as an educational adviser in India. Professor Frederick S. Orcutt, formerly professor of bacteriology, has been named acting head of the Department of Biology. Dr. J. M. Grayson attended and presented an invitation paper on insect resistances to insecticides at the Fourth International Congress of Crop Protection, held in Hamburg, Germany, September 8-15. Drs. E. C. Turner, Jr., and E. M. Raffensperger attended a work conference on systemic insecticides at Kerrville, Texas, on July 9-11. This work-shop was sponsored by the Entomology Research Service of the U.S.D.A. and several chemical companies which are developing chemicals for use as systemic insecticides. Dr. W. G. Evans attended the Eastern Alfalfa Improvement Conference held at Storrs, Connecticut, on July 15-17, where he served as a panel leader for discussion of the alfalfa weevil. Dr. J. R. Rooney, II, Professor of Animal Pathology, Biology Department, has returned from 12 months leave of absence; during this period he studied in the Royal Veterinary College, Stockholm, Sweden. Dr. W. E. Field, a graduate of Michigan State College and Wayne University, has joined the staff of Animal Pathology Section, Department of Biology as Assistant Professor of Animal Pathology. Dr. William Van Dresser, a Michigan State graduate in Dairy Science and in Veterinary Medicine, has joined the staff of Animal Pathology, Biology Department. Dr. C. J. Ackerman, Associate Biochemist, Virginia Agricultural Experiment Station, Blacksburg, was on leave for a 6-week period during the summer of 1957; Dr. Ackerman served as chief biochemist on a nutrition survey team in Lybia, North Africa. Dr. P. C. Holt, Assistant Professor of Biology, has been awarded an NSF grant in the sum of \$58000 for a period of approximately two years for "Systematic Studies of the Branchiobdellidae."

The radiation pit at The Blandy Experimental Farm was completed and the Cobalt-60 source was installed and put into operation beginning July 19, 1957. The radiation field, as well as the Orland E. White Arboretum, were open to visitors at a field day held on August 15.

Dr. Robert F. Smart has been named dean of Richmond College.

Dr. J. C. Strickland has been promoted to the chairmanship of the Department of Biology at the University of Richmond.

Dr. J. D. Burke of that department was appointed research fellow of the American Physiological Society for the summer of 1957 and spent the time working with Dr. F. G. Hall in the Department of Physiology at Duke University.

Dr. W. R. Tenney formerly of West Virginia University and of Camp Detrick, Maryland — whose main interest is the physiology of fungi — has been appointed Assistant Professor in the department.

—Walter S. Flory, *Blandy Experimental Farm,*  
*University of Virginia*

### CHEMISTRY SECTION

New members of the Research and Development Department of Virginia-Carolina Chemical Corporation are: Donald E. Hayford, Chemist, graduate of the Virginia Polytechnic Institute; Miss Margaret Anne Barber, Chemist, graduate of the University of South Carolina; James J. Anderson, Senior Chemist, PhD from the University of Virginia; C. F. Booth, Section Leader, General Engineering Development, former President of the Covington Fertilizer Company in Andalusia, Alabama; and Brooks M. Whitehurst, Senior Chemist Engineer, formerly with American Enka Corporation. Promotions announced in the Research and Development Department are: John M. Daniel, Jr., from Senior Chemical Engineer to Section Leader-Fertilizer Process and Mechanical Development; Robert B. McDaniel, Jr., from Patent Coordinator to Section Leader-Administration and Services; C. F. Booth, from Senior Development Engineer to Section Leader-General Engineering Development; J. P. Crowder from Senior Engineer to Group Leader-Fertilizer Process.

Dr. Bryant Harrell has received a grant from the National Institutes of Health which enabled him to carry on research at the College of William and Mary during the summer months on his project: "Synthetic Respiratory Pigments." The grant is subject to renewal for the next four years.

Under another grant from the Research Corporation for the summer of 1957, with the assistance of a recent William and Mary graduate, Edward David Eanes, Dr. Harrell devised an improved method for the "Quantitative Microanalysis of Alkoxy Groups."

From the Virginia Institute of Scientific Research —

Dr. Henry Leidheiser, Jr., participated in the International Symposium on Passivity held in Darmstadt, Germany, in early September. Sev-

eral countries took part in this conference including the United States, England, Italy, Germany, Japan, Czechoslovakia, and Norway. Dr. Leidheiser presented a paper entitled "Anaerobic Corrosion of Metals in Solutions Containing Various Metallic Cations — Passivation and Activation." Before his return home, he visited several universities in England.

Dr. Leidheiser also attended the Gordon Conference on Corrosion. Dr. R. A. Lefever attended the Gordon Conference on the Chemistry and Physics of Metals, and Dr. Carl J. Likes the Conference on Adhesion.

Mr. W. Roger Buck, III, attended the Buffalo meeting of the Electrochemical Society which was held in October.

A new addition to the staff of the Institute is Mrs. Lucille B. Garmon, a 1957 graduate in chemistry from the University of Richmond.

Dr. Karl Killer, a native of Switzerland, who joined the staff in November of 1956, has completed his year's work in electrochemistry and is returning to Europe.

October 21 through 25 the Institute sponsored its first Science Book Fair. Over 350 books from twelve leading science publishers were on display, current publications on chemistry, physics, metallurgy, and biochemistry. A book fair is planned for spring and fall each year.

#### From the Virginia Polytechnic Institute —

Dr. L. K. Brice has been promoted from assistant professor to associate professor.

Dr. E. F. Furtch has been promoted from Associate Professor to a Full Professor.

Dr. R. C. Krug has been awarded an American Chemical Society-Petroleum Research Fund Grant for 1957-58. James A. Rigney, formerly of the Research Division of the American Cyanamid Co., Bound Brook, New Jersey, is working under this grant as an A.C.S. Graduate Fellow.

In September 1957 Dr. Krug was one of the first recipients of the W. E. Wine Achievement Awards for distinguished teaching. Dr. Krug was the recipient of the award in the School of Applied Science and Business Administration.

Mr. W. L. McPherson for the past year has been in charge of the planning and equipment procurement for the new radiochemical laboratory. This laboratory and its attendant class room work is a part of the Nuclear Engineering Program inaugurated this year. Professor McPherson is the graduate of several of the Oak Ridge Institute of Nuclear Studies courses as well as being a research participant in the Analytical Chemistry Division of the Oak Ridge National Laboratory.

Dr. J. W. Murray taught in the Summer Institute for High School Science Teachers June 10 through July 29. He also engaged in analytical consulting work for the Department of Geology.

Dr. Jack Vanderryn for the past three summer months has been engaged as a research participant at Oak Ridge National Laboratories. His work concerned the infrared spectroscopy of boron trifluoride and its addition compounds.

Dr. F. A. Vingiello in July attended the XVth International Congress of Pure and Applied Chemistry meeting in Paris, France. In addition to attending the meeting he gave a talk on "An Unusual Elbs Type Reaction Observed During a Study of the Cyclization of Ketones."

The National Institutes of Health has just established a \$24,000 project here for work on benzopyrenes under Dr. Vingiello's direction.

Dr. J. W. Watson is the Councilor for the Virginia Blue Ridge Section of the American Chemical Society.

—M. A. Kise, *Virginia Smelting Corporation*

## ENGINEERING SECTION

Professor Frank C. Vilbrandt of the Chemical Engineering Department at the Virginia Polytechnic Institute has been appointed to the Board of Authenticators and Advisors for revision of the *New Standard Encyclopedia*. His duties will include checking each article submitted in the field of engineering for accuracy and coverage. In September Dr. Vilbrandt attended the New York meeting of the American Chemical Society, and in October he attended a meeting of chemical engineering professors at Rochester, New York, at the invitation of Eastman Kodak Company.

Professor F. W. Bull of the Chemical Engineering Department at the Virginia Polytechnic Institute attended industrial meetings of chemical engineering professors held by Esso Standard Oil Company in Baton Rouge, Louisiana; Hercules Powder Company in Wilmington, Delaware; International Paper Company in Georgetown, South Carolina; Koppers Company in Pittsburgh; the du Pont Company Experiment Station in Wilmington, Delaware; and the Texas Company in Beacon, New York. Professor Bull has announced that Mr. Russell A. Primrose and Mr. Julian F. Mote have been added to the Virginia Polytechnic Institute as Assistant Professors of Chemical Engineering.

Professor Nelson F. Murphy of the Chemical Engineering Department at the Virginia Polytechnic Institute was co-author of the Virginia Polytechnic Institute Engineering Experiment Station Bulletin, entitled,



"Melting Point Diagram for the System Sodium Cyanide-Sodium Carbonate." In October Dr. Murphy attended the Buffalo, New York meeting of the Electrochemical Society. In October he accompanied the senior chemical engineering students on a one-week inspection trip to chemical plants in New Jersey, Maryland, and Virginia.

A school for chemical engineering teachers, sponsored by the du Pont Company, was held in October in Charleston, West Virginia. Attending this meeting were Professors F. C. Vilbrandt, F. W. Bull, and N. F. Murphy from the Virginia Polytechnic Institute, and Professors R. M. Hubbard and O. L. Updike from the University of Virginia.

Professor Robert W. Truitt of the Aeronautical Engineering Department at the Virginia Polytechnic Institute has published a paper in the *Journal of the Aeronautical Sciences* entitled, "Flow Over Blunt-Nosed Bodies."

Mr. Tilton E. Shelburne, director of the Virginia Council for Highway Investigation and Research, attended the meeting of the National Advisory Committee to the AASHO Road Test at Ottawa, Illinois in August. He presented a paper on the design and performance of flexible pavements at the Atlanta meeting of the Southeastern Association of State Highway Officials in October. Mr. Shelburne was installed as Director for District Six of the American Society of Civil Engineers at the annual meeting held in October in New York City. Mr. James L. Eades, also of the Virginia Council for Highway Investigation and Research, presented a paper describing the recent work done by the Council on the stabilization of soils at a meeting of technical advisors to The National Lime Association in Washington in October.

Engineering Dean Lawrence R. Quarles of the University of Virginia has announced that the University has been selected as one of the schools participating in the special AEC fellowship program in Nuclear Energy Technology. He has appointed Dr. J. L. Meem as Professor of Nuclear Engineering and Director of the Nuclear Research Reactor Facility. In June and October Dr. Quarles attended meetings of the Board of Directors of the American Nuclear Society in Pittsburgh and New York. In September he attended the meeting at the Virginia Military Institute of the Research Advisory Committee of the Virginia Council of Highway Investigation and Research.

Members of the engineering school of the University of Virginia attending the June meeting of the American Society for Engineering Education held at Cornell University were Dr. L. R. Quarles and Dr. Otis L. Updike.

Professor Orville R. Harris, director of the University of Virginia

Engineering Experiment Station, attended the Frequency Control Symposium sponsored by the Signal Corps Engineering Laboratory at Asbury Park, New Jersey in May. In June Dr. Harris and Dr. Otis L. Updike attended a school on the operation of the PACE electronic computer, since one has been acquired by the School of Engineering of the University of Virginia, held at Princeton, New Jersey computation center of Electronics Associates. In September Dr. Harris attended the President's Conference on Technical and Distribution Research for small businesses held in Washington.

Professor R. M. Hubbard of the Chemical Engineering Department at the University of Virginia has returned from leave of absence for one year. During part of this time he traveled extensively through the Southern, Southwestern and Western parts of the United States, visiting the chemical industry and chemical engineering schools in those areas. During his absence, Professor R. E. L. Gildea substituted as editor for the Engineering Section. Professor Gildea has recently been commissioned by the United States Public Health Service as Senior Sanitary Engineer in the inactive reserve.

Mr. Bernard A. Niemeier has joined the Reynolds Metals Company, Metallurgical Research Laboratory, as head of the mechanical and structural testing group. During the past summer he attended a summer session on stress analysis held at Massachusetts Institute of Technology. He has been appointed to the Committee on Fatigue of the American Society for Testing Materials.

—Robert M. Hubbard, *University of Virginia*.

## GEOLOGY SECTION

Chauncey G. Tillman joined the staff of the Virginia Polytechnic Institute Department of Geological Sciences in September 1957 as associate professor. He received his B.S. in Geology from the University of Michigan in 1950 and his M.S. from the same school in 1952. He has completed his course-work towards his Ph.D. from Harvard University. During parts of 1950, 1951, 1953, and 1954, Mr. Tillman was employed as a geologist by the Mineral Deposits Branch of the U. S. Geological Survey and worked on the Florida Phosphate Project and in Nevada and Utah in mine evaluation work in association with the Defense Minerals Exploration Administration program. Mr. Tillman's main interests are Paleozoic paleontology and stratigraphy.

Mark Fara was added to the staff of the Virginia Polytechnic Institute of Geological Sciences in January 1957, as assistant professor. Mr. Fara obtained his B.S. and M.S. degrees in geology from the Virginia Polytechnic Institute in 1956 and 1957, respectively. His thesis dealt with

the geology of the Parnassus, Virginia, quadrangle.

Douglas Neil Hillhouse joined the Virginia Polytechnic Institute Department of Geological Sciences as a part-time instructor in September 1957. He is also working toward his Doctor's degree. Mr. Hillhouse received his B.A. (Honors) in 1955 and his M.Sc. in 1956 from the University of British Columbia. During the 1956-57 academic year he was assistant professor at Texas Western College, El Paso, Texas. From 1951-53 Mr. Hillhouse was employed in the geophysical department of Shell Oil Company in Alberta. He spent the summers of 1954 and 1955 doing stratigraphic work for the same company in the Northwest Territories. He spent the summer of 1956 doing field work in southwestern British Columbia for the Geological Survey of Canada and the British Columbia Academy of Sciences and the summer of 1957 doing stratigraphic work for Pan American Oil Corporation in the southern Canadian Rockies.

"Geology of the Clifton Forge Iron District, Virginia," by Frank G. Lesure has been published as Bulletin No. 118 of the Engineering Experiment Station Series of the Virginia Polytechnic Institute publications. The bulletin, accompanied by a 42 x 56-inch colored geologic map, may be procured from the Director, Engineering Experiment Station, Blacksburg, Virginia.

B. N. Cooper was a Distinguished Lecturer for the American Association of Petroleum Geologists during April and May, 1957. He lectured on "Appalachian Folding, A Control of Paleozoic Sedimentation in the Appalachian Geosyncline" before 27 affiliated societies and university departments of geology from coast to coast. On September 13, he spoke before the Illinois Geological Society meeting jointly with the Indiana and Western Kentucky Geological societies at Mt. Vernon, Illinois. On October 25, he gave his AAPG lecture at the annual meeting of the Kentucky Geological Society in Lexington, Kentucky. During 1957, he has served as a member of the VALC Committee on Water Resources and as chairman of the sub-committee on ground water.

Bruce W. Nelson attended the Sixth National Clay Conference held in Berkeley at the University of California, August 19-23, 1957. On October 19-20, he took 9 of the Virginia Polytechnic Institute graduate students in sedimentation to the York River area to study erosion and transportation in the headwaters and deposition in the estuary. He is currently studying sedimentation in this area in connection with a research project under the auspices of the Virginia Engineering Experiment Station.

The official opening of the new Virginia Polytechnic Institute Field Station was an "Open House" held on July 14, 1957, which was at-

tended by approximately 250 persons. The Station was erected by the Olin Mathieson Chemical Corporation for the Virginia Polytechnic Institute Department of Geological Sciences. Part of the furnishings of the building was donated by several Virginia mineral industries and public utilities. The Station is located on a hill overlooking Broady Bottom Bend on the North Fork of the Holston River. The building contains 3,200 square feet of floor space with provision for 24 students and 3 staff members. The building includes a large fully-equipped kitchen and a dining-lounge area. Students from three schools took the regular field course between June 15 and July 28, and thereafter, a few students continued to work on special or thesis problems dealing with the local geology.

The Virginia Polytechnic Institute Department of Geological Sciences has been loaned a Frost gravity meter through the courtesy of Dr. G. P. Woollard of the University of Wisconsin. C. E. Sears of the Virginia Polytechnic Institute Department of Geological Sciences has begun a gravity survey of southwestern Virginia.

The current program of the Geologic Division of the U. S. Geological Survey in Virginia includes the following projects. Geologic field investigations with L. D. Harris in charge are being completed in the Stickleysville quadrangle in northeastern Lee and western Scott counties. The studies of the stratigraphy and structure of this complex area are designed to provide further data that are needed to appraise the oil and gas potential of the area. Studies by J. T. Hack and others are now underway in the Potomac River basin that are primarily concerned with geomorphic processes in the watershed. The purpose is to provide basic data in the evaluation of hydrologic concepts and to test the use of certain hydrologic principles as aids in the study of land forms. Currently the studies are concentrated on the soils and other surficial deposits in the Shenandoah Valley, and a map is being prepared to show the different kinds of weathered debris of that part of the watershed. A paper on the origin of the meanders of the Shenandoah River is now being prepared by Mr. Hack in collaboration with R. S. Young. Studies are also in progress of a cross-sectional area through the southern Appalachian folded belt, including the extreme southwest tip of Virginia. J. G. Stephens is in charge. The work includes detailed geologic mapping, sub-surface and geophysical investigations. This project is part of a plan to develop an integrated picture of the stratigraphy, tectonic history, and interrelationships between the Cumberland Plateau, the southern Appalachian folded belt of southwestern Virginia and northeastern Tennessee, and the Blue Ridge and Piedmont Provinces of North Carolina. The work is designed also to gather data needed to evaluate the oil and gas potential of the southern Appalachians and provide a better understanding of the geologic setting affecting the emplacements of ore deposits that

occur in this region. An area near Galax, Virginia of about 500 square miles has recently been test flown by airborne magnetometer and radio-activity methods. The resulting data are being evaluated in an attempt to make a three fold correlation between the geology, the airborne radio-activity data, and the aeromagnetic data.

—W. D. Lowry, *Virginia Polytechnic Institute.*

### PSYCHOLOGY SECTION

Professor Frank A. Geldard returned to the University of Virginia in September after a year's leave of absence in London as Scientific Liaison Officer with the U. S. Office of Naval Research. Professor Geldard arranged and chaired a symposium on military psychology in connection with the International Congress of Psychologists held at Brussels in July, and during the year he reported the research being conducted at the University of Virginia to various groups of European psychologists.

A number of psychologists participated in the 1957 meetings of the American Psychological Association in New York. Dr. Frank W. Finger delivered the presidential address before the Division of Teaching Psychology; his topic was "Toward the Improvement of Teaching." Dr. Finger also jointly authored, with Dr. L. S. Reid, a paper, "The Effect of Previous Reinforcement upon Revolving Wheel Activity during Prolonged Food Deprivation." Dr. K. E. Lloyd read a paper, "Retention and Transfer of Responses to Classes of Stimuli." Dr. W. F. Battig was chairman of a session of papers on Concept Formation, and he also presented a paper on "The Effects of Previous Experience and Information on Performance on a Word Formation Problem." Dr. F. A. Geldard participated in a symposium featuring a report from the International Congress of Psychology, and Dr. S. B. Williams was a member of a symposium considering the topic, "Key Concepts in Psychology." Dr. F. J. McGuigan chaired a paper session on Discrimination Learning and presented a paper entitled, "A Test of the Discriminative Stimulus: Secondary Reinforcement Hypothesis."

On October 2, Dr. Allen D. Calvin spoke to the University of Minnesota Psi Chi chapter on the topic of inhibition of reinforcement.

On October 30, at a meeting of the Armed Forces-NRC Committee on Bioacoustics, Dr. Geldard read a paper on the mechanical aspects of tactual communication. At this same meeting, Dr. J. F. Hahn read a paper on the electrical aspects of tactual communication.

The Research Unit of Aging at the Veterans Administration Center,

at Kecoughtan (Hampton), was established last spring to conduct basic research in the psychology of aging and to investigate chronic illnesses as psychological phenomena. The staff consists of Dr. Neil W. Coppinger and Dr. Rayford T. Saucer.

Several institutions report additions to their staff. The University of Richmond has appointed Dr. Jay Clark and Dr. Robert Johnston as Assistant Professors of Psychology. Dr. Harold Payne has become Chief Psychologist at the Memorial Guidance Clinic, and Dr. Robert Gibby is now Chief Psychologist at McGuire Veterans Hospital. Dr. Paul J. Woods has joined the staff at Hollins College, and Mr. William Buckley has been appointed to the Psychology Staff at Eastern State Hospital.

—John K. Bare, *College of William and Mary*.

#### STATISTICS SECTION

Dr. Ralph A. Bradley, Professor of Statistics at the Virginia Polytechnic Institute was elected a fellow in the American Statistical Association at the 1957 annual meeting at Atlantic City, New Jersey. He was also appointed Acting Editor of Biometrics and is in the process of moving the Office of Biometrics from Ottawa, Canada to the Virginia Polytechnic Institute.

Dr. John E. Freund and Dr. R. L. Wine have resigned their positions in the Department of Statistics of the Virginia Polytechnic Institute to accept positions at Arizona State College; Tempe, Arizona and Hollins College; Hollins, Virginia, respectively.

The Department of Statistics of the Virginia Polytechnic Institute has the following new members:

1. H. A. David, Professor of Statistics, received his Ph.D. degree from the University of London.
2. John Hemelrijk, Visiting Professor, received his Doctor of Science degree from the Municipal University of Amsterdam, Holland.
3. David C. Hurst, Associate Professor, received his Master of Science degree from North Carolina State College and is completing his requirements for his Ph.D. degree this fall.
4. Leroy S. Brenna, Assistant Professor, received his Master's degree from Kansas State College.
5. James R. Duffett, Assistant Professor, received his Master's degree from the University of Florida.
6. William A. Glenn, Assistant Professor, received his Bachelor of

Arts degree from the University of New Brunswick, Canada.

The Mountain Lake Conference on Statistics sponsored by the Department of Statistics of the Virginia Polytechnic Institute and the Southern Regional Education Board was held August 22-27, 1957. Approximately fifty scientists enjoyed an outstanding program. At the time of these meetings, the Committee on Statistics of the Southern Regional Education Board also held its business meeting.

The Department of Statistics of the Virginia Polytechnic Institute received a grant from the Public Health Service for a cooperative training program in conjunction with the Medical College of Virginia to train statisticians. The Department of Statistics was also awarded a contract to make an Analytical Index for the journals of the American Statistical Association covering Volumes 35-50 from the years 1940 to 1955.

A. E. Garratt, Leo Lynch, and Robert N. Pendergrass have fulfilled their requirements for their Ph.D. degrees in Statistics. Dr. Garratt is now with Telecomputing Corporation in New Mexico; Dr. Lynch is with United States Steel Corporation in Monroeville, Pennsylvania; and Dr. Pendergrass is teaching at Radford College, Radford, Virginia.

Mr. Jonas M. Dalton and Miss Beverly Anne Wales have fulfilled their requirements for their Master of Science degrees in Statistics. Mr. Dalton is now working at Bell Telephone Laboratories; Murray Hill, New Jersey. Miss Wales is teaching school on Long Island, New York.

—R. A. Bradley, *Virginia Polytechnic Institute*.









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### NOTICE TO CONTRIBUTORS

Contributions to the Journal should be addressed to Robert T. Brumfield, Stevens Hall, Longwood College, Farmville, Virginia. If any preliminary notes have been published on the subject which is submitted to the editors, a statement to that effect must accompany the manuscript.

Manuscripts must be submitted in triplicate, typewritten in double spacing on standard 8½" x 11" paper, with at least a one inch margin on all sides. Manuscripts are limited to seven pages, with the proviso that if additional pages are desired, the author may obtain them at cost. The author may estimate the length of his paper by counting the total number of characters, including blank spaces, and dividing this by 3300. The result is the approximate number of printed pages in the Journal.

Division of the manuscripts into subheadings must follow a consistent plan, and be held to a minimum. It is desirable that a brief summary be included in all manuscripts.

Footnotes should be included in the body of the manuscript immediately following the reference, and set off by a dashed-line above and below the footnote content. Footnotes should be numbered consecutively from the beginning to the end of the manuscript.

Bibliographies (Literature Cited, References, etc.) should be arranged alphabetically according to author. Each reference should include the date, full title of the article, the name of the Journal, the volume, number (optional), pages, tables and figures (if any). For example: "Sniffen, Ernest W. 1940. Cobbles from the Pleistocene Terraces of the Lower York-James Peninsula Va. Journ. Sci., 1 (8): 235-238 1 fig., 1 tab. Reference to the bibliographic citations should not be made by numbers. Instead, using the above citations, where a reference is desired: either "Sniffen (1940)", (Sniffen, 1940: 186)", or "Sniffen (1940) states that . . ."

Explanation of figures, graphs, etc., should be typed on separate pages. All figures should be numbered consecutively beginning with the first text figure and continuing through the plates. If figures are to be inserted in the text this should be clearly indicated by writing "Figure —" at the appropriate place in the margin.

Illustrations including lettering, should be arranged so that on reduction they will not exceed the dimensions of the maximum size of a printed page. 4-1/2" x 6-1/2", and so that they are well balanced on the page. Large plates must be accompanied by 8-1/2" x 11" photographic copies which can be sent to the reviewers. The Journal will furnish the author with one plate (halftone or line reproduction) or its equivalent; additional figures, colored illustrations or lithographs may be used only if the author makes a grant covering the cost of production. Original drawings (which must be done in black drawing ink) not photographs of drawings, should accompany the manuscript. Photographs should not be used if a line and dot (stippled) drawing will suffice. If photographic prints are to be used they should be glossy, sharp and show good contrast. Drawings not neatly executed and labeled (do not use a typewriter), or which are submitted on yellow or yellowish-white paper will not be accepted.

Galley Proofs and engraver's proofs of figures are sent to the author for correction. Costs of excessive changes from the original manuscript must be defrayed by the author.

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## Notes on the Helminths of Mammals in the Mountain Lake Region.<sup>1</sup> Part 3

### The Genus Centrorhynchus in North America, With the Description of a New Species<sup>2</sup>

HARRY L. HOLLOWAY, JR.

*Department of Biology, Roanoke College*

The genus *Centrorhynchus* is a well defined group of "spiny-headed" worms belonging to the family Polymorphidae (Meyer, 1931), Palaeacanthocephala (Meyer, 1931), and class Metacanthocephala (Van Cleave, 1948). The species of this genus usually reach sexual maturity in the alimentary tract of birds. The most striking feature of this genus is the origin of the proboscis receptacle at approximately the mid-point of the longitudinal axis of the hook-covered introvert. The confusion which existed in the early anatomical studies of this genus, due to the attachment of the proboscis receptacle in the middle of the proboscis, has been clearly resolved by Van Cleave and Bullock (1950). They defined the praesoma as the region from the cuticular collar or ring to the cephalic tip of the proboscis. The praesoma is then dichotomously separated into the neck and proboscis — the proboscis being the region from the hind edge of the basal root of the posterior hooks to the cephalic tip and the remainder of the praesoma is the neck. The neck is short and unspecialized. Since the point of attachment of the proboscis receptacle is not concerned with

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<sup>1</sup>This investigation was supported in part by research awards from the National Science Foundation through Dr. Bruce D. Reynolds, Director of Mountain Lake Biological Station, during the summers of 1954, '55 and '56.

<sup>2</sup>From a dissertation submitted to the Graduate Faculty of the University of Virginia in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

demarking these gross body regions, there should be no confusion in anatomically separating the divisions of the praesoma.

The genus is poorly represented in North America, probably because of a lack of sampling. Five species have been attributed with certainty to the fauna of North America.

Van Cleave (1916) notes that Leidy in 1888 recorded the occurrence of "*Echinorhynchus caudatus* Zeder" in the swallowtail kite (*Elanoides furcatus*) and an owl (*Strix nebulosa*) and continues that it is impossible to determine whether the Acanthocephala described belongs to the genus *Centrorhynchus* or *Mediorhynchus*. In 1916 Van Cleave described *Centrorhynchus spinosus* from an egret (*Herodias egretta*). The specific description was based on one immature female. Later Van Cleave (1940) discovered that he had misinterpreted Kaiser's (1893) description of *Echinorhynchus spinosus* from an unrecorded host from Florida. Van Cleave (1940) notes that several birds from Florida have been listed as hosts for this species.

Millzner (1924) described *Centrorhynchus californicus* upon the basis of encysted juveniles from the mesenteries of *Hyla regilla* (Pacific Coast tree frogs) captured in California. This species has not been encountered since Millzner's original description.

Ward (1940) recorded the occurrence of eleven encysted juveniles of an unidentified species of *Centrorhynchus* from the intestinal wall of *Natrix sipedon* (water snake) from Kentucky.

Van Cleave and Pratt (1940) described *Centrorhynchus conspectus* from *Strix varia varia* Barton (Barred owl) taken in North Carolina.

Van Cleave and Williams (1951) recorded the occurrence of *Centrorhynchus scanensis* Lundstrom, 1942, from *Ixoreus naevius naevius* (Gmelin) (Pacific varied thrush) taken from Douglas Island and near Juneau, Alaska. This species was described by Lundstrom (1942) from *Turdus merula merula* Linnaeus in Sweden. This is the only known species of this genus recorded from both the European and North American continents. Van Cleave and Williams (1951) suggest that the accidental introductions of the parasites by wandering birds and not seasonal migrants is the only plausible explanation of the distribution of *Centrorhynchus scanensis*.

Read (1950) was able to infect experimentally albino rats with *C. spinosus* recovered from the body cavity of *Thamnophis sirtalis* (snake) captured near Houston, Texas. Twenty-eight days after feeding, he recovered mature specimens from the two experimentally fed rats. Although *C. spinosus* had previously been reported only from birds of



prey, Read notes a few species of this genus have been reported from mammals. *C. ninni* (Stossick, 1891) was described from *Putorius vulgaris* in Europe and its presence has been observed in this same species by several Italian workers; Chandler, in 1925, described *C. erraticus* from a cat taken in Calcutta; Fukui, in 1929, described *C. itatsinis* from *Luterola itatsi itatsi* in Japan and Meyer, in 1932-33 reported immature specimens of *C. aluconis* (Muller, 1780) from *Felis catus*. Read (1950) states further that *C. ninni* may or may not ordinarily be a parasite of mammals. *C. spinosus* will develop either in birds or mammals, thus indicating that physiological host specificity is not high in the species and that it may not be strongly developed in members of this genus.

According to Read (1950), the researches of Chandler (1941), Lincicome (1943 and 1948), Moore (1946) and his own work indicate that the proboscis characters attain a static state, as far as taxonomic characters are concerned, quite early in the ontogeny of the worm. This static state is attained in the intermediate host when the worm is capable of establishing itself in the definitive host.

*Centrorhynchus wardae* sp. nov.

(figs. 1-8)

In July, 1954, the author recovered five specimens of the genus *Centrorhynchus* from the alimentary canal of *Spilogale putorius* (L.) The host was trapped at Castle Rock, approximately two miles northeast of the Mountain Lake Biological Station in Giles County, Virginia.

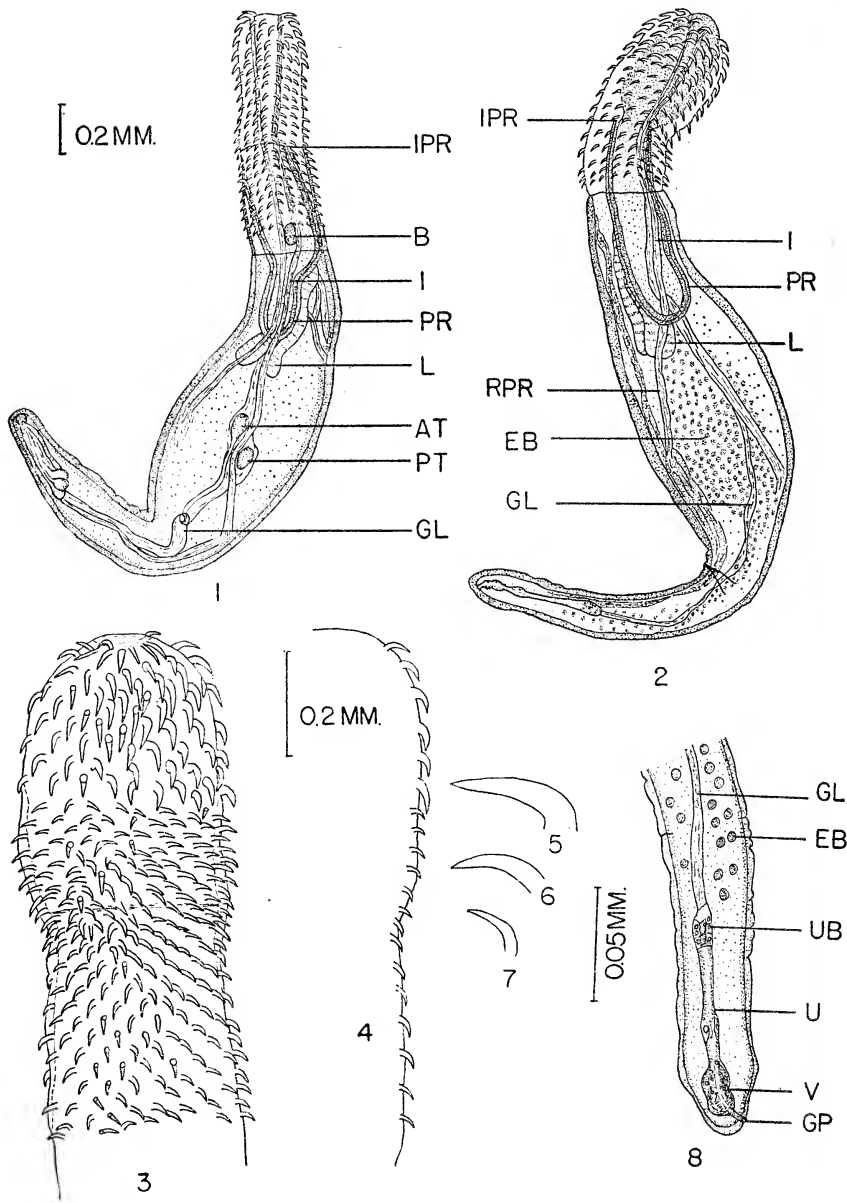
A detailed study of the specimens revealed distinct differences from previously described species of this genus and hence they are recognized as belonging to a new species, here described as *Centrorhynchus wardae*. The specific name is in honor of Dr. Helen L. Ward, University of Tennessee, a student of the Acanthocephala.

In an abstract concerning this species, the author (1956) created a *nomen nudum* in that the type specimens were not designated. However, the description and designated types of *Centrorhynchus wardae* included in this paper should rectify that error.

The specimens are only slightly morphologically advanced over described encysted juveniles of this genus from frogs and snakes. However, since the proboscis characters are the primary specific characters in this group and because they have attained a stable state in their development, there would be no difficulty in recognizing it upon later encounters.

Measurements are in millimeters and were determined with an ocular micrometer. Drawings were made with the aid of a camera lucida.

The worms are shaped somewhat like small swords — the praesoma



corresponding to the handle, and the trunk, although slightly bent toward the ventral side, resembles the attenuated blade (figs. 1 and 2). The males (fig. 1) are 3.000 mm. in length, with a maximum diameter, slightly posterior to the midpoint of the longitudinal axis, of 0.508 — 0.562 mm. The females (fig. 2) are slightly larger than the males, having a total length of 3.815 — 4.125 mm., and a maximum diameter, slightly posterior to the midpoint of the longitudinal axis, of 0.594 — 0.636 mm. The proboscis (figs. 3 and 4) is 0.791 — 0.989 mm. long, (cephalic extremity to the caudal edge of the root-thorn junction of the most posterior hooks). It is 0.495 — 0.695 mm. long from the insertion of the proboscis receptacle to the cephalic extremity, and 0.265 — 0.396 mm. in length from the insertion of the proboscis receptacle to the caudal edge of the root-thorn junction of the posterior hooks. The enlarged portion of the proboscis is 0.353 — 0.480 mm. in diameter, and the posterior portion is 0.269 — 0.396 mm. in diameter. The proboscis receptacle inserts (IRP, figs. 1 and 2) slightly caudad to the midpoint of the longitudinal axis of the proboscis. The proboscis (figs. 3 and 4) is arrayed with numerous closely-set hooks. There are approximately 34 to 36 longitudinal rows of 18 to 20 hooks each. The hooks are of two distinct types (figs. 3, 4, 5, 6 and 7). The first five hooks (fig. 5) of each longitudinal row are more sturdy and strongly recurved than the posterior ones (figs. 6 and 7). The remaining hooks decrease gradually in size caudally. Although the roots are not all distinct, the anterior hooks appear to possess a well-developed root which becomes poorly developed in the medial hooks and appears to be absent in the basal hooks. The thorns of the anterior hooks (fig. 5) measure 0.049 — 0.069 mm., thorns of medial hooks

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Figs. 1-8. The morphology of *Centrorhynchus wardae*. The scale to the left of fig. 1 applies to figs. 1 and 2. The scale between figs. 3 and 4 applies to figs. 3, 4, and 8. The scale to the right of figs. 6 and 7 applies to figs. 5, 6, and 7.

Fig. 1. Immature male. AT, anterior testis; B, brain; GL, genital ligament; I, invertors of proboscis; IPR, insertion of proboscis receptacle; L, lemniscus; PR, proboscis receptacle; PT, posterior testis. Fig. 2. Immature female. EB, egg balls; GL, genital ligament; I, invertors of proboscis; IPR, insertion of proboscis receptacle; PR, proboscis receptacle; L, lemniscus; RPR, retractor of proboscis receptacle. Fig. 3. Proboscis. Fig. 4. Profile view of the proboscis. Note the size differentiation of the lateral hooks. Fig. 5. Anterior hook from the proboscis. Fig. 6. "Medial" hook from the proboscis. Fig. 7. Posterior hook from the proboscis. Fig. 8. Optical section of the posterior extremity of an immature female, GL, genital ligament; GP, genital pore; EB, egg balls; U. uterus; UB, uterine bell; and V. vagina.

measure 0.033 – 0.049 mm. (fig. 6) and the thorns of the basal hooks measure 0.023 – 0.036 (fig. 7).

The praesoma is separated from the body proper by a cuticular ring or collar. It is not sharply differentiated from the body proper.

The lemnisci (figs. 1 and 2) measured from the insertion of the proboscis receptacle to the caudal tip are 0.989 – 1.060 mm. long. They are of equal length and extend into the body cavity only a short distance past the caudal edge of the proboscis receptacle.

The proboscis receptacle (PR, figs. 1 and 2) is a two-layered cylindrical muscular sac. In one preparation (fig. 1) the distal third of this sac appeared to be slightly constricted and the invertors of the proboscis passed through its apex. The invertors (I, figs. 1 and 2) of the proboscis extend from the apex of the proboscis to the blind end of the proboscis receptacle, where they pass through as the dorsal and ventral retractors of the proboscis receptacle (RPR, figs 1 and 2). They terminate in the sub-hypodermal musculature of the body wall.

What appears to be the "brain" (B, fig. 1) lies between the invertors of the proboscis slightly anterior to the cuticular collar.

The testes (AT, PT, fig. 1) are poorly developed and they lie in a rather wide genital ligament (GL, fig. 1). They are oval in shape and measure 0.069 – 0.082 mm. long and 0.043 – 0.053 mm. wide. A vas efferens arises at the caudal apex of each testis and passes posteriorly along the dorsal and ventral edge of the genital ligament. The two ducts were traced to the anterior edge of the four rather poorly differentiated cement glands. The anatomy of the male reproductive system between the cement glands and genital pore is poorly developed and obscure. The genital pore is sub-terminal. The genital ligament appears to extend from the posterior edge of the proboscis receptacle to the cement glands.

The lumen of the trunk in the female contains many poorly differentiated egg balls (EB, fig. 2). A genital ligament (GL, fig 2) extends from the caudal edge of the proboscis receptacle to the cephalic edge of the uterine bell. The uterine bell (UB, fig. 8) is not well differentiated and is not inflated (non-functional). Several nuclei are visible in the uterine bell. A tube-shaped non-specialized uterus (U, fig. 8) connects the uterine bell with the vagina (V, fig. 8). This latter organ is shaped like a figure 8; the anterior dilation appears cellular and the distal portion muscular. The distal dilation of the vagina is connected to the sub-terminal genital pore by a short, unspecialized portion of the vagina.

The trunk of both the male and the female is spineless.

Type Host – *Spilogale putorius* (Allegheny Spotted Skunk).

Type Locality — Giles County, Mountain Lake, Virginia.

Types: Holotype female and allotype male — U. S. N. M

Helm. Coll. No. 38200. Series of paratypes in the author's collection.

The Allegheny Spotted Skunk is probably not the normal definitive host of *C. wardae*, but, in the light of Read's (1950) work, it is not outside the realm of possibility that it might mature in this host. The host was an adult lactating female. In an attempt to throw some light on the life cycle of this form, the stomach contents were analyzed. Portions of *Ambystoma* species were recovered and, since several species of the genus *Centrorhynchus* have been recovered from amphibia as encysted juveniles, it is probable that the skunk picked up the worm in this manner. A list of the identifiable invertebrates in the alimentary canal follows:

Diplopoda

Tulidae — not identified further.

Arachnoidea

Araneae — not identified further.

Insecta

Hymenoptera

Formicidae

*Pheidale* Sp.

*Solenopsis molesta* (Say)

*Aphaenogaster rudis picea* Em.

*Camponotus hercullanus pennsylvanicus* (DeGeer)

Others unidentifiable

Coleoptera

Staphylinidae — unidentifiable

Coccinellidae

*Cycloneda munda* (Say)

Rhyncophora (Cuculionidae)

*Lipidophorus setiger* Horn

Others unidentifiable

Lepidoptera

Geometridae — not identified further

Homoptera

Membracidae

*Platycotis vittata*



2. The analysis of the gastric contents of *S. putorius* revealed that the skunk probably became infected upon ingesting *Ambystoma* species. The identifiable invertebrates recovered are listed.

3. *Centrorhynchus californicus*, *C. wardae*, *C. spinosus*, *C. conspectus*, and *C. scanensis* from the fauna of North America are compared and a key to the species is given.

### Acknowledgments

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TABLE I. COMPARISON OF RECOGNIZED SPECIES  
MEASUREMENTS

	Number Longitudinal Rows of Hooks	Number Hooks Per Row	Length of Hooks			
			Anterior	"Medial Hooks"	Posterior	
<i>californicus</i>	48	21 to 22	.052	.042	.031	
<i>wardae</i>	34 to 36	18 to 20	.049 to .069	.033 to .049	.023 to .036	
<i>spinosus</i>	30 to 34	22 to 24	.036 to .060 Hooks of two Distinct Types			
<i>conspectus</i>	generally 26 to 28 sometimes 30 to 32	generally 17 to 18 extremes 16 to 19	generally .050 to .065 extremes .044 to .073	.050 to .060 extremes .039 to .065	.040 to .057	
<i>scanensis</i>	22	10 to 11	.030 to .054			



# GENUS CENTRORHYNCHUS FROM NORTH AMERICA

## MILLIMETERS

Anterior	Posterior	Embryos	Body Dimensions	Proboscis Receptacle	Length of Lemnisci	Host
	Posterior					
Shows no difference between anterior and posterior			Artificially excysted juveniles 3.150 by .140-.380	.940 by .360	.540	<i>Hyala regilla</i> (Pacific Coast tree frogs) (Abdominal mesentery)
	.269 to .396		Immature specimens in small intestine. Male 3.000 by .508-.562 Female -3.815 -4.125 by .594-.636	.579 .805 long	.989 to 1.060	<i>Spilogale putorius</i> (Allegheny Spotted Skunk) (small intestine.)
	.350	.050-.060 by .020-.024	Female -40-66 by 1.500. Male 30-45 by .900-1.100			<i>Herodias egretta</i> (egret) (intestine.)
region swollen, ed at insertion is receptacle wed by a short portion.	.060-.078 by .021-.026		Female 28-55 by 1.000-1.500 Male 23-35		Extend 1.500 beyond proboscis receptacle.	<i>Strix varia varia</i> (Barred owl) (small intestine.)
.400 anterior ovoid, and or portion con-	.078-.084 by .021-.024		Female 10.000-14.500 by 1.500-1.800. Male 7.400-8.300 by 1.000	1.000 long	1.000 to 1.400	<i>Ixoreus naevius naevius</i> (Pacific varied thrush)



TABLE 1. COMPARISON OF RECOGNIZED SPECIES OF GENUS *CENTRORHYNCHUS* FROM NORTH AMERICA  
MEASUREMENTS IN MILLIMETERS

	Number Longitudinal Rows of Hooks	Number Hooks Per Row	Length of Hooks			Length of Proboscis		Embryos	Body Dimensions	Proboscis Receptacle	Length of Lemnisci	Host
			Anterior	"Medial Hooks"	Posterior	Anterior	Posterior					
<i>californicus</i>	48	21 to 22	.052	.042	.031	shows no difference between anterior and posterior portions.			Artificially excysted juveniles 3.150 by .140-.380	.940 by .360	.540	<i>Ilyala regilla</i> (Pacific Coast tree frogs) (Abdominal mesentery)
<i>wardae</i>	34 to 36	18 to 20	.049 to .069	.033 to .049	.023 to .036	.33 to .40	.269 to .396		Immature specimens in small intestine. Male 3.000 by .508-.562 Female -3.815 -4.125 by .594-.636	.579 .805 long	.989 to 1.060	<i>Spilogale putorius</i> (Allegheny Spotted Skunk) (small intestine.)
<i>spinosus</i>	30 to 34	22 to 24	.036 to .060 Hooks of two Distinct Types			.30 to .35	.350	.050-.060 by .020-.024	Female -40-66 by 1.500. Male 30-45 by .900-1.100			<i>Herodias egretta</i> (egret) (intestine.)
<i>conspectus</i>	generally 26 to 28 sometimes 30 to 32	generally 17 to 18 extremes 16 to 19	generally .050 to .065 extremes .044 to .073	.050 to .060 extremes .039 to .065	.040 to .057	proboscis region swollen, retracted at insertion, proboscis receptacle followed by a short undilated portion.		.060-.078 by .021-.026	Female 28-55 by 1.000-1.500 Male 23-35		Extend 1.500 beyond proboscis receptacle.	<i>Strix varia varia</i> (Barred owl) (small intestine.)
<i>scanensis</i>	22	10 to 11	.030 to .054			to .400 anterior portion ovoid, and anterior portion con-		.078-.084 by .021-.024	Female 10.000-14.500 by 1.500-1.800. Male 7.400-8.300 by 1.000	1.000 long	1.000 to 1.400	<i>Ixoreus naevius naevius</i> (Pacific varied thrush)

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# Origin Of The Blue Ridge Escarpment Directly Southwest Of Roanoke, Virginia<sup>1</sup>

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## INTRODUCTION

Most of the observations reported upon in this paper were made in Floyd County which is directly southwest of Roanoke, Virginia. The area is of special interest so far as determining the origin of the Blue Ridge Escarpment because part of the country is within the irregular mountain ridges subdivision of the Blue Ridge Province and part of it is within the upland subdivision of the province (fig. 1).

## THE BLUE RIDGE PROVINCE

The Blue Ridge Province is a long, narrow area that extends from south-central Pennsylvania through Maryland, Virginia, Tennessee, and North Carolina to northwestern Georgia. Northeast of Roanoke, Virginia, the Blue Ridge Province consists essentially of an irregular mountain ridge that ranges from a single ridge with width of less than two miles to a complex group of ridges with an overall width of ten to twelve miles. Southwest of Roanoke, the province is a slightly to highly dissected upland that ranges up to nearly seventy miles in width. The differences between these two rather distinct parts of the province are mainly the result of their different drainage histories. Northeast of Roanoke both sides of the province are characterized by rather well defined escarpments and both sides are drained by tributaries of streams that flow to the Atlantic Ocean. Southwest of Roanoke the Blue Ridge is a broad upland bordered on the east by the prominent Blue Ridge Escarpment and on the west by an irregular group of mountains, the Blue Ridge Front Mountains. The Blue Ridge Escarpment is drained by tributaries of Atlantic Coast Streams whereas most of the Upland is drained by tributaries of streams that flow westward to the Gulf of Mexico. From Floyd County, water that flows to the ocean via Gulf of Mexico drainage system arteries travels as much as 5.5 times as far as that which reaches the ocean via direct Atlantic slope streams (Gannett, 1901).

## BLUE RIDGE ESCARPMENT

Early literature concerning the Blue Ridge Escarpment was summari-

<sup>1</sup>This is a summary of a paper presented at the meeting of the Southeastern Section of the Geological Society of America held at Morgantown, W. Va., May 17, 1957.

zed by Davis (1903). Different modes of origin for the escarpment were discussed by Wright (1927) and later summarized by Fenneman (1938). White (1950) wrote the most recently published paper concerned chiefly with the origin of the escarpment.

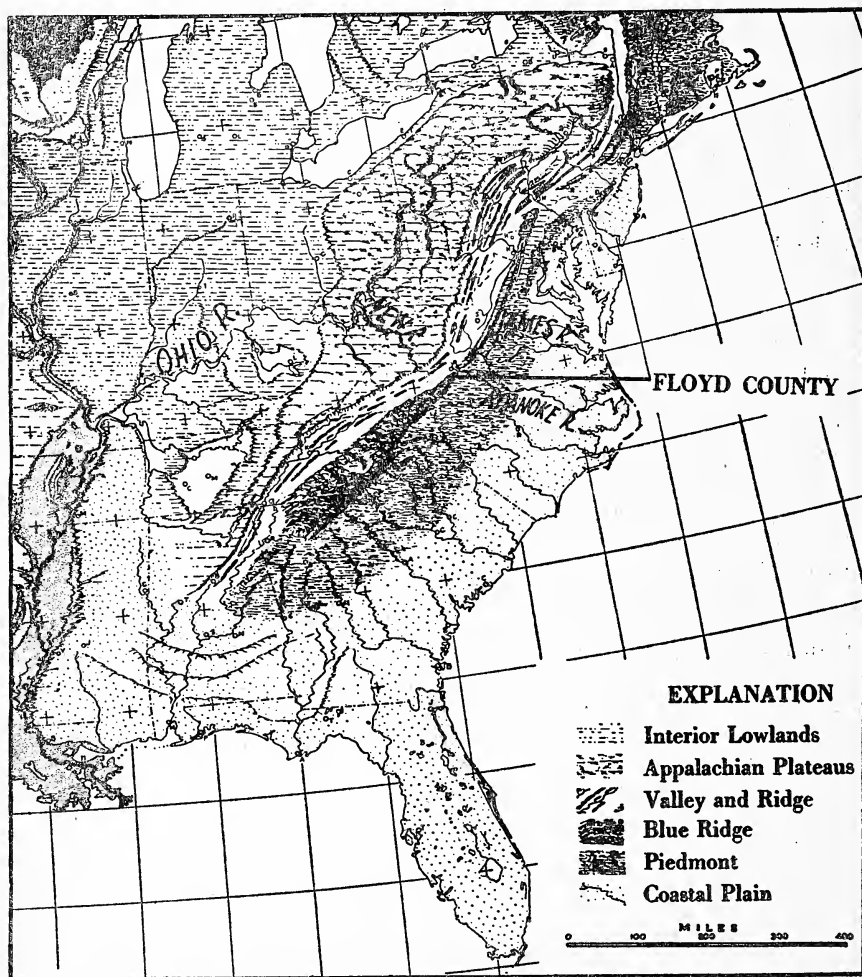


Fig. 1. Physiographic diagram of the eastern United States with location of the Floyd County area indicated. (Base map, copyright A. K. Lobeck; reprinted by permission of A. K. Lobeck and The Geographical Press, a division of C. S. Hammond & Company.)

There is no general agreement in the literature concerning the origin of the Blue Ridge Escarpment. Possible modes of formation which have been considered are: 1) marine erosion along a sea cliff, 2) erosion controlled by a marked superiority of resistance to weathering and erosion of the rocks of the Blue Ridge over resistance to weathering and erosion of the rocks of the Piedmont, 3) monoclinical flexing, 4) faulting, 5) westward migration of an asymmetric divide, and 6) different combinations of these. The discussion presented here, although it is necessarily somewhat general, pertains mainly to the part of the escarpment along the southern border of Floyd County.

The possibility that the Piedmont represents a surface of marine planation and that the Blue Ridge Escarpment was formed originally as a sea cliff has never been considered seriously, so far as the writer knows. Triassic sedimentation on the Piedmont; the absence of Jurassic sediments on either the Piedmont or beneath the late Mesozoic and Cenozoic Coastal Plain sediments; Cretaceous and Cenozoic sedimentation, much of which is reported to be of near shore type, on the site of the present Coastal Plain; and ocean terrace formation on the Coastal Plain during the Pleistocene can be offered as at least permissive evidences against this possible genesis for the escarpment in post-Paleozoic time. Formation of the present escarpment or even of an ancestral escarpment by marine erosion (or by any other means) before Triassic block faulting appears to be highly unlikely when one considers the positions of some of the border faults of the Triassic troughs in relation to the Blue Ridge.

The possibility that the escarpment was formed as a consequence of erosion controlled by the presence of relatively resistant rocks underlying the Blue Ridge and the presence of relatively less resistant rocks underlying the Piedmont is untenable. The Lynchburg formation underlies much of Floyd and Carroll counties of the Upland and also much of Franklin and Patrick counties of the adjacent Piedmont. Nearly all of the diverse rocks that constitute this formation appear to offer nearly the same resistance to weathering and erosion. Further, the lithological contacts that are present are not parallel to the scarp.

Monoclinical flexing as the control that initiated formation of the Blue Ridge Escarpment was first suggested as a possibility by Hayes and Campbell (1894). Johnson (1933) and Fenneman (1938) apparently also believed that warping ("differential uplift") may have been at least locally important. In the opinion of the writer, the structure of the involved areas is not known sufficiently well to rule out or to support this idea. However, data obtained during reconnaissance geologic mapping of the areas involved plus some of Wright's (1928) observations, *e.g.*, "... the Piedmont surface juts into the base of the Blue Ridge." (*op. cit.*, p. 329), pose definite difficulties for this hypothesis.

The possibility that the Blue Ridge Escarpment is some type of fault or fault line scarp has appealed, at least momentarily, to nearly everyone who has made only cursory examination of the escarpment or of topographic maps that include the feature. Few geologists have championed the hypothesis. Fenneman (1938) reported that Campbell believed faulting was important so far as formation of certain segments of the escarpment. White (1950:1309) concluded that "The Present Blue Ridge scarp seems to have been produced by a late Tertiary fault — the Blue Ridge border fault." Stose and Stose (1951), in a short discussion, cited evidences that appear to be incompatible with White's hypothesis — at least for part of the eastern escarpment.

Considerations of the main arguments given in favor of the fault-control hypothesis show that: 1) The suggestion that the presence of an escarpment on the east and lack of one on the west is incongruous, disregards two facts; (a) there are broad outcrops of resistant Silurian, Mississippian, and Pennsylvanian sandstones in the western part of the Valley and Ridge Province west of the province which have acted as temporary base levels for westward flowing drainage, and (b) there is an escarpment, one nearly as imposing as the eastern escarpment, along the western boundary of that part of the Blue Ridge Province drained by Atlantic Slope streams rather than by Gulf streams. 2) Statements concerning the necessity that the escarpment be a divide throughout its length do not consider the possibility of any stream piracy of upland streams by Atlantic Slope streams. 3) The straightness of a line constructed so as to connect the foot of the spurs of the escarpment has long been a "bone of contention" (Davis, 1903; Wright, 1927; White, 1950; and White, 1953). In the present writer's opinion, if the topography along the escarpment between the North Carolina-Virginia state line and a point just south of Roanoke, Virginia, is examined on recent aerial photographs (pl. 1), and/or topographic sheets (Elliston and Stuart, Virginia quadrangles and Bluefield, West Virginia, Virginia, Kentucky and Winston Salem, North Carolina, Virginia, and Tennessee Army Map Service Topographic Sheets), it is quite apparent that, no matter what criteria are used to locate the terminations of the spurs, a line connecting them would not be straight but extremely irregular (fig. 2). 4) The idea that the west-flowing streams must have undergone an uplift which did not affect the east-flowing ones because of the discrepancy in degree of their rejuvenation

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Plate 1. Part of the Blue Ridge Escarpment; the area is located 22 miles southwest of Roanoke and 22 miles southeast of Blacksburg; approximate scale of aerial photograph is 1:20,000; bottom of photograph is east. (Photographed by U. S. Department of Agriculture, Soil Conservation Service.)





nation appears to overlook the alternatives that rejuvenation of the upland streams may represent the removal of one or more temporary base level(s) at the western edge of or downstream from the upland, the shortening of the overall distance that waters of these streams have to travel to reach the ocean as the result of the establishment of the Ohio River, or a combination of these. 5) So far as the suggestion that out-

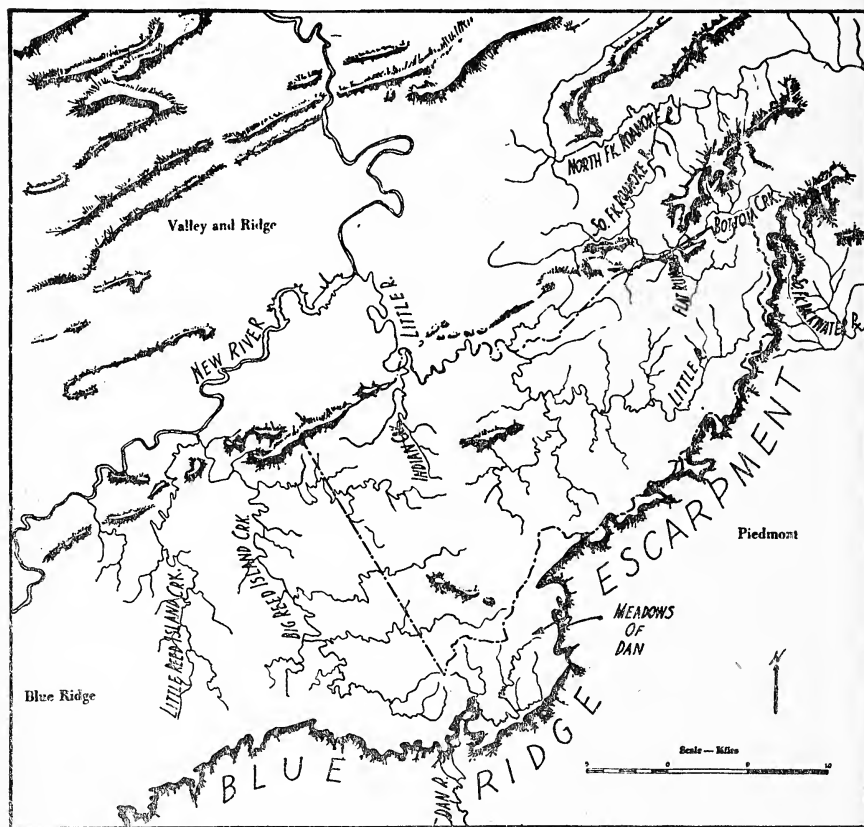


Fig. 2. Diagram showing the Blue Ridge Escarpment of southwestern Virginia, some of the Blue Ridge Front Mountains, and the main drainage arteries of Floyd County and adjacent region. (Bases for this diagram are Blacksburg, Elliston, and Stuart, Virginia U. S. G. S. quadrangle sheets and Bluefield, West Virginia, Virginia and Kentucky and Winston-Salem, North Carolina, Virginia, and Tennessee Army Map Service Topographic sheets.)

lying mountains along the foot of the escarpment may be topographic correlatives of the higher mountains on the upland, in the area under consideration here, the outlying mountains in front of the escarpment as defined by White would fit into his scheme: Chestnut, Smith, and Turkeycock mountains are 700 to 900 feet above the surrounding Piedmont, which correlates well with the fact that Buffalo Mountain and Wills Ridge in Floyd county are, respectively, approximately 1,000 and 800 feet above their surrounding upland hilltops. Further, these figures are notably less than the height of the escarpment of the area. However, if the criteria commonly used to fix the position of the escarpment of North Carolina were employed to fix its position in this area, such prominences as Bull Mountain (3212 feet) and perhaps even Cahas Knob (3560 feet) and Rocky Mountain (2910 feet) would be considered as on the postulated downthrown block. These mountains, considered as outlying mountains on the Piedmont, not only have approximately the same elevations as the adjacent upland (2600 to 3100 feet), they have no counterparts atop the adjacent upland. 6) Conditions such as those cited by White, for certain areas where the trace of the postulated fault transects many different types of rocks do not obtain in this area.

The only tangible structural evidence offered with respect to the actual position of the postulated "Blue Ridge border fault" was the presence of minor faults and slickensided surfaces parallel to schistosity of crystalline rocks of the Piedmont and of "offsets" along the escarpment. White (1950) placed emphasis on the fact that he was able to find slickensided surfaces and other phenomena in roadcuts close to the trace of the postulated fault. If a fault were to be located objectively in the area southeast of the escarpment adjacent to Floyd County by using the same criteria, the conclusion would be that an extremely wide belt (actually nearly all of the area west of the Fall Line) constitutes a fault zone. One of the "offsets" in the escarpment was located as near the eastern end of Floyd County. This "offset" (the one located as ". . . near Callaway and Junta (Christiansburg, Virginia — West Virginia Sheet), where the displacement is about 3 miles.") is not apparent to the writer on the more recent, larger scale Elliston quadrangle sheet that supercedes the Christiansburg sheet. Further, if this "offset" exists, Cahas Knob (see above) would be on the downthrown block. Also, examination of this area has failed to reveal any evidence of a cross structure of the magnitude suggested.

Because of these data the writer can not support the fault control hypothesis of origin for the Blue Ridge Escarpment of this area. Nonetheless, he would be hesitant to deny emphatically the possibility that the escarpment is some type of erosional fault scarp. If such be the case, however, it would appear that the original fault scarp must have existed far southeast of the present erosional scarp and also that, at

least along part of its length, it would have been an appreciable distance southeast of White's (1950) postulated "Blue Ridge border fault." (No such fault has been recognized to date.)

The hypothesis that the Blue Ridge Escarpment of southwestern Virginia and North Carolina was formed by erosion accompanying westward (northwestward) migration of the asymmetric divide between Atlantic Slope Drainage and Gulf of Mexico Drainage and that the escarpment may have evolved to, rather than originated as, an escarpment was introduced by Davis (1903). Subsequent workers (*e.g.*, Wright, Fenneman, Thompson) have embraced this idea at least to the extent that they have noted that erosion attending migration of the divide has sculptured the escarpment to its present appearance. Thompson (1939) noted that in his opinion "... the divide has been migrating northwestward for a long time and is in places as much as 100 miles northwest of its original position."

Apparently no one has denied the fact that the present escarpment owes most, if not all, of its present appearance to weathering and erosion accompanying the westward migration of the asymmetric Atlantic-Gulf Divide. The obvious headward growth of the vigorous streams of the escarpment as they encroach upon the drainage basins of the upland streams, the piracies of Gulf drainage by Atlantic streams, and numerous other features attest to this. However, the possibility that the escarpment actually originated as a consequence of the westward migration of the divide is not so readily accepted.

Many features mentioned above appear to favor this hypothesis. A few additional features not considered, or at least not elaborated upon, are also pertinent. 1) Nearly all mountains of the southern part of the Piedmont Province of Virginia are within five to twelve miles of the Blue Ridge Escarpment. 2) With few exceptions, the outlying mountains decrease in height and number with increased distance from the escarpment. 3) Alluvial boulder deposits occur locally on the upland near the escarpment. 4) The distance between the headwaters of main Atlantic slope streams and the coast are essentially equal from the Potomac River southward; *i.e.*, all main streams have nearly equal lengths with deviations from this, easily explainable when comparisons of resistances of bedrocks along the stream courses and lengths of courses derived by piracy are considered. 5) The Piedmont Province is about 30 miles wide at the Potomac and about 160 miles wide in southern Virginia. 6) The width of the Blue Ridge Province and the heights of its prominences in general increase in magnitude from northeast to southwest. 7) Geophysical work suggests (Miller, 1937) that there probably was continuous or intermittent eastward tilting in this region during most of Mesozoic and Cenozoic time.

The location and distribution of mountains along the foot of the escarpment is exactly what one would deduce as a consequence of westward migration of the highly asymmetric Gulf-Atlantic divide; they are difficult to correlate with any of the other hypotheses unless activities set up under those hypotheses are applied to the area southeast of the outliers. The presence of large stream valleys, swamps along valleys, and alluvial boulder deposits on the upland near the escarpment indicates the former presence of large streams there. This suggests that a sizable part of the Gulf drainage area previously existed east of the present escarpment. (The loss of headwaters, of course, also could be accounted for by warping, or by faulting as well as by migration of the divide.) The facts concerning the widths of the area drained by the Atlantic Slope streams and of the Piedmont Province considered in conjunction with the fact that the Blue Ridge is, in general, higher, broader, and less deeply dissected in the southern part than in the northern part of Virginia, not only appear to be consistent with the divide-migration hypothesis but appear to require that any hypothesis of origin for the escarpment be combined with this hypothesis if it is to warrant serious consideration. Corroborative data are: 1) nearly all Atlantic Slope streams are essentially perpendicular to the general slope of the land except where they have courses underlain by relatively nonresistant rocks (Thompson, 1939); 2) areas crossed by the streams and underlain by resistant rocks are typically sites of residual mountains and ridges; and 3) the prominences nearer the coast are more highly dissected than are those farther from it — apparently because the ones nearer have been attacked on all sides by the more vigorous Atlantic Slope streams for longer periods than the ones more remote from the ocean. Further, if the area did undergo eastward tilting throughout much or most of Mesozoic and Cenozoic time, Atlantic Slope streams certainly would have been steepened and thus would have had their advantage over Gulf streams not only maintained but possibly even increased intermittently; this would have prompted migration of the divide throughout the period.

Different combinations of hypotheses, *i.e.* eclectic hypotheses, of origin for the escarpment are innumerable. Those most commonly suggested combine warping or faulting with subsequent erosion along the westward migrating, asymmetric Atlantic-Gulf Divide. It is quite possible that one of these combination hypotheses will prove to be correct.

In summary, the present writer believes that the data favor the hypothesis embracing formation of the escarpment as the result of the westward migration of the asymmetric Atlantic-Gulf of Mexico Divide. It appears that the Blue Ridge Province, from one end to the other, was at one time essentially an upland drained mainly to the west; that the area was attacked by eastward flowing streams; that these streams breached the upland and then attacked the breached portions from all sides; and that dissection

thus initiated led to detachment of areas from the main upland to form distinct ridges and mountains. If this sequence of events is correct, apparently the Blue Ridge to the northeast of Floyd County has passed through this whole sequence of events, the Upland of Floyd County and to the southwest has not been breached and thus retains pre-breaching characteristics, and the intervening northeastern part of Floyd County and the area adjacent to the northeast have the characteristics of intermediate steps in the sequence. It is obvious that this last named area was part of the Upland at one time and it is equally obvious that the features that indicate this will not persist long, geologically speaking, and that the area then will be indistinguishable from the Blue Ridge Mountain Ridge (s) to the northeast.

### GEOMORPHIC HISTORY

All reported data appear to fit best into the following general geomorphic history. As will become apparent, many of the suggested events have been introduced previously (note especially Fenneman, 1938, and Thompson, 1939, and 1949).

Evidence indicates that New River probably existed in Mississippian time and possibly earlier (Branson, 1912; Shuler, 1945). It probably has flowed westward throughout its history. Although the Blue Ridge intermittently may have had less relative prominence than it has at present apparently it has been some sort of topographic barrier since at least late Paleozoic and possibly since late Precambrian time. The Blue Ridge may occupy essentially the position of, although it probably is west of, the ancient divide between the "Appalachian Geosyncline" and the basins represented by metamorphosed Paleozoic sediments to the east. Any evidence of events during the period between the end of Paleozoic sedimentation and establishment of the Mississippi Embayment-Atlantic Divide prior to Triassic block faulting appears to have been obscured beyond present day recognition. In any case, none has been recognized to the present. Immediately preceding the high angle faulting of the Palisades Disturbance, the Blue Ridge was much less prominent than it is today. On the east, the boundary of the Blue Ridge with the area now designated Piedmont Province would have been a nearly symmetrical divide between the eastward - and westward-flowing streams. On the west, it would have been essentially continuous, geomorphologically though not lithologically, with the area now known as the Valley and Ridge Province. The stage in the classical geomorphic cycle reached in this area at that time can only be guessed - conceivably, although doubtfully, the mature surface now represented on the Upland was formed as early as this. The divide between the eastward - and westward-flowing streams would have been east of the present Gulf of Mexico-Atlantic Divide. The presence of

boulders of Paleozoic sedimentites in the Triassic Potomac Basin suggests that the Potomac or an ancestral Potomac already had part of its course west of the position of the present Blue Ridge or that Paleozoic sedimentites existed at the western edge of that basin at that time. The fact that no Paleozoic sedimentite fragments have been found to occur in the Triassic Basins south of the Potomac Basin plus the apparent control of the northeastward-flowing parts of the courses of the James and Roanoke rivers by these basin areas suggest that these two master streams probably had not attained the position of the present Blue Ridge-Valley and Ridge boundary by this time, *i.e.*, the area underlain by the Paleozoic sedimentites drained by westward-flowing streams. The ancestral divide, especially south of the Potomac, may have been shifted as a result of Palisades faulting. After this faulting and consequent Triassic sedimentation and before initiation of Cretaceous sedimentation in the area that includes and is east of the present Coastal Plain, there was erosion that involved at least partial planation of both crystalline rocks and Triassic sedimentites (Spangler and Peterson, 1950). It would have been during this planation that the so-called Fall Zone peneplane was formed. By the time Cretaceous sedimentation began and possibly prior to that time, distance-to-base level advantage of the eastward-flowing streams over that of the westward-flowing streams already had been established, regardless of whether the westward-flowing waters emptied into the Mississippi Embayment or into the ocean via the stream that flowed through the present position of Lake Erie and its trunk stream. Because of this advantage, the eastward-flowing streams were destined to render the divide asymmetric and to encroach upon the drainage basin of the westward-flowing streams. At least intermittently throughout the late Mesozoic and Cenozoic, encroachment proceeded — possibly enhanced by warping, eustatic changes in sea level, or a combination of these — so the area drained by the westward-flowing streams became relatively reduced in size while the area drained by the eastward-flowing streams became enlarged. After the James and Roanoke rivers eroded headward, in turn, to the position of the present eastern border of the Valley and Ridge province, reduction of the drainage areas of the westward-flowing streams was hastened not only because the area underlain by the relatively nonresistant calcareous and argillaceous sedimentary rocks was then attacked by the more vigorous Atlantic streams but also because major streams of the subsequent drainage systems of the Valley and Ridge Province flowed in a direction nearly perpendicular to the Atlantic slope streams which meant that their capture by the Atlantic streams involved relatively large drainage areas. Further, the more resistant rocks of the Blue Ridge Province also were reduced more rapidly after this boundary was attained by the Atlantic Basin streams because they then were attacked not only on the east but on many sides by the vigorous streams of the Atlantic Basin. As this process continued the Blue Ridge Province has been and contin-

ues to be reduced to a series of linear ridges and individual mountains drained to the east. The change in general character of the Blue Ridge Province from a broad upland to a series of linear ridges and mountains has progressed from northeast to southwest because the northeastern part of the province is nearer the present (and previous) coast line than is its southwestern part. Unless interrupted these processes will continue until all of the present day Blue Ridge Province has been reduced first to a series of ridges and mountains and finally to the point that, other than grainwise, the Piedmont and Valley and Ridge provinces will be geomorphologically continuous, with no intervening Blue Ridge, and drained to the east. The changes in character will, of course, be preceded by changes of features of the Valley and Ridge subprovince south of the Roanoke-New Divide into features more similar to those of the Valley and Ridge subprovince northeast of this divide. The ultimate, if natural or artificial changes do not interrupt the cycle in such a way as to preclude it, will be the establishment within or west of the Appalachian Plateau of an essentially symmetrical Atlantic-Gulf divide at an elevation near sea level.

Probably few, if any workers would deny that uplift has played a part in the geomorphic history of the region. The great volume of sediments that comprise the Coastal Plain sequence attest to this, especially if they were derived mainly from the area between the Fall Zone and a divide east of the present Blue Ridge. To the present, no evidence, marine sedimentation records notwithstanding, has been found that clearly indicates definite spatial and temporal aspects of such uplift. The presence of at least some of the coarse sediments in the Coastal Plain and Mississippi Embayment-Gulf of Mexico sequences, for example, may reflect removal of temporary base levels, eustatic changes in sea level, changes in climate, or a combination of such controls rather than uplift. Certainly at least some of such controls rather than uplift. Certainly at least some of the recent (Pleistocene and post-Pleistocene) rejuvenation (s) can be attributed to differences in stream volumes mainly dependent upon changes in rainfall; to relative elevation above sea level dependent upon changes in sea water volume in response to glaciation(s) and deglaciation(s); and, as is in the case of New River, to changes in overall distance from headwaters to the ocean — the inception of the Ohio River certainly shortened the distance between the headwaters of New River and the ocean. (Perhaps even the recent rejuvenation of New River, which is indicated by downcutting in old alluvial deposits along the edges of which are perched colluvial deposits whose relatively long stability is indicated by marked disintegration of included quartzite boulders, reflects one or more of these controls rather than uplift.)



## SUMMARY

The topography and drainage of the area directly southwest of Roanoke in southwestern Virginia, are of peculiar interest because the area is located at the boundary between two more-or-less distinct parts of the Blue Ridge Province — the irregular mountain ridges drained by Atlantic Coast streams and the dissected upland drained almost wholly by streams of the Gulf of Mexico Drainage Basin. Evidence here suggests that the location, as well as the character, of the present Blue Ridge Escarpment is the result of migration of the asymmetric Atlantic-Gulf Divide.

A general geomorphic history is suggested for the province for the time subsequent to the late Paleozoic establishment of New River.

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## Report On A Gastrotrichan Species From Ashland, Virginia

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Search for *Polymerurus* in a water sample taken from a garden pool July 31, 1956, on the college campus, revealed a chaetonotid gastrotrich of graceful body similar in shape to that of *Lepidodermella squamata*. Its somewhat tessellated appearance and extraordinarily long spines, which originated a third to a half the distance from the anterior end, were distinctive. Long spines occurred laterally at 3 spaced posterior levels, all extremely sharply pointed. The first and most conspicuous were arranged in a semicircular fashion about the widest part of the main body like a hoop skirt. Anteriorly, the neck and the head bore short thorns with basal plates roughly rhomboidal as in *Polymerurus*. Hairs were dimly visible protruding through the mouth opening. The intestine was coarsely granular. Two clear vesicles appeared posteriorly, one per side. The head was weakly 5-lobed with a pair of clear, lateral bodies. This particular specimen did not stop twisting, turning, bending, straightening and moving about.

Four subsequent collections yielded a total of 10 individuals positively identified as being alike. Two additional specimens, observed under the dissecting binocular and thought to be of the same chaetonotid species, were transferred into crystallization dishes of pool water. It was hoped that they would adjust to the changed conditions and multiply within doors. Repeated checking of the containers failed to show that they did so.

An attempt was made to kill, fix, and mount 3 of the 10 animals with unsatisfactory results. Studies and measurements of the 7 others were carried out following immobilization by  $MgSO_4$ , iodine, Schaudinn's fixative, and formalin. No chemical solution used was effective in relaxing or fixing the animals in a state of really good extension.

### Historical Review

Voigt (1904) published several accounts of the Gastrotricha of the waters of Plon. Among these was *Chaetonotus succinctus* n. sp., recovered from a small garden pool among *Utricularia* plants, in October and

November. Its total body length was 217-225 micra. Other measurements listed were:

Esophagus length	49.5 micra
Toe length	33 — 39 micra
Back spine length	78 micra
Lateral toe spine length	63 micra
Head width	39 micra

How many specimens he found or measured is not known, evidently more than one. The above records may represent, then, several to many individuals.

Konsuloff (1914) described the alleged species, obtained in April in Bulgaria, as "rare." His measurements were:

Animal length	193 micra
Esophagus length	41 micra
Head scale length	3.2 micra
Head spine length	4.8 micra
Back spine (rear) length	72 micra
Back scale (rear) length	3.4 micra
Head width	35.5 micra

No ranges are given here to indicate that more than one individual was studied for measurement.

Remane (1935-36), a recognized gastrotrichan authority, has supplied meager descriptions of *C. succinctus*. He placed it in the same group with *C. acanthodes* Stokes. Stokes (1918) was the early microscopist who discovered and described in New Jersey so many of our gastrotrichan forms. His brief description of *C. acanthodes* in the citation shows that there is rather close general similarity between it and *C. succinctus*. The most conspicuous feature of both is, perhaps, the mid-body circlet of very long spines which extend posteriorly around the animal like the ribs of a partly closed umbrella-half. Probably the major difference is the furcation of the recurved "body" spines observed by Stokes (l. c.) in *C. acanthodes*. Figures of *C. succinctus*, in Remane (l. c.) for example, have no forking of either short or long spines.

The figure by Stokes (l. c.) of the posterior portion of *C. acanthodes* lacks the transverse row of long spines. Those which are shown are unfurcated. There is no enlarged diagram of either short or long spines. Ward and Whipple (1918) reproduced the same figure, p. 627. The diagram shows no small, supplementary scale of the larger basal plate from which it is said the spine springs.

*C. succinctus* was seemingly next discovered by Saito (1937) in August and September in a *Lotus* pool in the vicinity of Hiroshima. Among the measurements taken for an undetermined number of animals are those for total length, 226 micra, head width 39 micra, and toe length, 33 micra, exactly as Voigt (l. c.) found. None of these corresponds to those taken by Konsuloff (1914).

Brunson (1950), reporting on 18 species of gastrotrichs from Michigan, describes *C. trichostrichodes* n. sp. as ". . . the only species of *Chaetonotus* yet found that has its spines in a transverse band across the back." It would seem that he is referring to his own findings for he does not cite the work of Voigt, Konsuloff, nor Saito in this particular paper. The transverse row of spines of Brunson (l. c.) is 5 in number, a "diagnostic" feature. They are unequally bifurcated ("singly barbed"), and ". . . the body covering appears scaled, but distinct individual scales were not seen". The head is distinctly 5-lobed. The animal's dimensions are less than those for *C. acanthodes* as given by either Voigt (l. c.) or Stokes (l. c.). It is not stated how many of these animals were measured or observed. The species would appear to qualify for the "acanthodes" category. Pennak (1953) reproduces this drawing as "B," though "modified from Brunson, 1950," in a plate entitled "Structure of various species of *Chaetonotus*." The spine bifurcations can be clearly seen though the species itself is undesignated.

Remane's (l. c.) brief characterization of *C. succinctus* mentions a "pharyngeal bulb," the very pointed spines with barbs, the escutcheon-like basal plates. Species of this group are said to be small to medium in size, inhabiting vegetation zones of fresh waters, especially in *Sphagnum* bogs.

Ashland specimens conformed closely to *C. succinctus*, in respect to descriptions and figures of external structure. Measurements were obtained for various parts with an ocular micrometer, on 5 specimens, which are shown in table I.

The measuring of gastrotrichs is difficult. Investigators, both here and abroad, include varying statistics on body parts in their studies. This is very likely due to the obstacles met in securing completely extended specimens; measurements of animals in the living state where they are rarely, if ever, wholly motionless; lack of sharply delineated landmarks for measurement; optical disadvantages to be overcome, and other factors. The animal may be prone, or seen laterally, or so placed that one body part may be seen from the dorsal position whereas another may be lateral or even dorso- or ventro-lateral. Gaps, therefore, in the above table occur because it was not always possible under existing conditions to obtain a reliable measurement.

Because an exact interpretation of measurements by the observers mentioned is impossible, a critical comparison of their findings with Ashland data is not too satisfactory. "Body length" with any of the 3 investigators could mean an overall measurement from front margin of head shield to posterior (distal) tip of toe, and probably does. Yet it might refer to the extent of the animal up to the midline point where the forked toes take origin. In the present study it is the former. Toe length, then, extends from distal tip forward to the trunk (rumpf) line level, with no easily determinable landmark line existing here for separation. Toe length is included, therefore, in the author's total, overall result.

There is variation in the measurements obtained for Ashland individuals. This is not too surprising inasmuch as a gastrotrich is hatched from the egg incompletely developed and comes to mature size as it feeds. An average of the 3 overall size lengths gives a figure of 168.2 micra which is less than any of the 3 other observers found. Esophagus length is possibly a more uniformly constant one in a species. Here a local read-

	1	2	3	4	5
Long post. rump spine	49.9	43.2			
Long post. lat. spine		56.6		59.9	
Short shank spine			13.3		
Short body spine			19.9		33.3
Body circlet spine		49.9		56.6	
Esophagus length			63.2	49.9	43.2
Toe length	23.3	23.3		33.3	49.9
Overall body length			166.5	178.1	159.8
Head width				26.6	33.3
Neck width				26.6	26.6
Body width				43.2	46.6

Table I. Dimensions in micra of five specimens of a gastrotrich from Ashland, Virginia.

ing is the same as that of Voigt (l. c.). Another is only slightly more than one of Konsuloff (l. c.). The toe length of an Ashland form is the same as that recorded by Saito (l. c.).

Considered from various viewpoints the size differences between the local and European specimens are not so great as to rule out the conclusion that the species are very likely the same. However, Brunson (l. c.), who has done the most extensive recently published work on the gastrotrichs in the United States expresses an interesting viewpoint; he says ". . . no one worker has studied or compared gastrotrichs from both Europe and North America, and so it is not known whether cosmopolitanism occurs in this group." Yet Pennak (1955) described the assemblage as cosmopolitan with respect to genera and their freshwater distribution. Brunson (l. c.) resumes ". . . until European material can be studied the author is assuming that the same species do not occur in both continents." He does make exception in the case of *Lepidodermella squamata* Dujardin. He was, possibly, unaware that Voigt (l. c.) discovered *C. acanthodes* of Stokes (l. c.) in Germany, or so designated it, for example. Also there seem to be no reports of gastrotrichs described for any part of North America but the United States.

So far as is known to this investigator the position taken by Brunson (l. c.) is unique with respect to gastrotrichan species. The opposite point of view is illustrated for *C. succinctus* because it is reported from Germany, Bulgaria, and Japan. It is felt, therefore, in the present case that *Chaetonotus succinctus* Voigt, or at least a closely related variant, has been discovered in the United States and reported from Ashland, Virginia, for the first time, a species described by Konsuloff (l. c.) as "rare."

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# A Procedure For Simultaneous Blood Volume Determinations Using Radioactive Phosphorus-32 And T-1824 (Evans Blue) Dye

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There are only two ways in which blood volume can be determined in an animal: directly and indirectly. In the direct method, as introduced by Welcker (1858), a blood sample of known volume is withdrawn and diluted with normal saline solution. This dilute solution serves as a comparative sample. Then as much blood as possible is removed by bleeding and tissue washings. The collected blood is diluted with water to match the color of the comparative standard. This dilute volume, divided by the dilution ratio of the standard, serves as a measure of the total blood volume. This method is not free from inherent errors such as those pertaining to clotting and blood collection.

The first indirect method of blood volume studies was reported by Valentin (1838). He injected distilled water into the circulation of an animal, and compared the blood solids of a prepared standard with the diluted blood solids of a withdrawn sample. Although hemolysis induced large errors, a stimulus was provided for other investigators using this method. Such substances as serum (Malassez, 1875; Nelson, 1909), sodium chloride (Sherrington and Copeman, 1903; Kottman, 1906; Plesch, 1909), antitoxin (Von Behring, 1911), foreign serum (Schurer, 1911), gum acacia (Meek and Gasser, 1918; Robertson and Bock, 1919; McQuarrie and Davis, 1920), and hemoglobin (Lee and Whipple, 1921) were among other substances used for determining blood volumes indirectly. These substances, in general, were not acceptable because they induced errors quantitatively and/or qualitatively.

The vital red dye series of study was introduced by Keith *et al.* (1915) whereby the plasma was tagged. Results of this investigation led others such as Dawson *et al.* (1920), Harris (1920), Hooper *et al.*

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(1920), and Graff and Clark (1931) into a qualitative investigation of various vital dyes regarding blood volumes. However, Dawson *et al.* (l. c.) recognized the superiority of blue over red dyes in animal experimentation. Their American dye (Chicago blue 6 B) was obtained in England as chlorazol sky blue FF by Elliott *et al.* (1934) who used this blue dye (T-1854) for determining fetal blood volumes colorimetrically.

In 1935 Gregersen *et al.* reported on the success of T-1824 (Evans blue) dye in determining plasma volumes. The principal points favorable to this blue dye was that its absorption range was removed from that of hemoglobin so that colorimetric and spectroscopic analyses could be made without introduced hemolytic errors, nontoxicity (Gibson and Gregersen, 1935), small rate of exocirculatory diffusion and non-absorption by red blood corpuscles (Gregersen and Schiro, 1938).

Tagging red blood corpuscles was first reported by Grehant and Quinquand (1882) wherein carbon monoxide was utilized. The inherent errors here lie in intra-tissue diffusion and instrumental analyses as pointed out by Reeve (1948). Hahn and Hevesy (1940) reported their successful attempt of tagging red corpuscles with radiophosphorus-32. This isotope can be handled advantageously since it is not a gamma emitter, has a relatively short half-life of 14.3 days, and exchanges readily with organic phosphorus in red blood corpuscles.

Thus, a study of blood volume investigations reveals that either the plasma or the red blood corpuscles must be tagged in order for a substance, to remain in the blood circulation long enough for sampling at time intervals. Therefore, calculated blood volumes are primarily delimited by quantitative and/or qualitative measurement. The chief factors related to blood volume delimitations are instrumentation, type of tagging substance, exocirculatory diffusion, turn-over rate and/or steady state equilibrium, and toxicity.

The procedure described below is the same as that used by Burke *et al.* (1953), and by Burke (1954) in determining blood volumes in different mammals such as rabbits, opossums, dogs, racoons, and swine. In comparing the determined blood volume values obtained by the P-32 and T-1824 methods by statistical treatment (in opossums), it was found that no statistical difference existed. Furthermore, these two methods (as described in the procedure) are particularly suited for animals weighing from one to 250 lbs. Blood volume in smaller or larger animals may be determined by modifying the procedure so as to vary the concentration of the injection dose of dye or P-32 labeled corpuscles. In the main, this procedure has been modified from Hevesy *et al.* (1943), Gregersen (1944), and Nachman *et al.* (1950).

## PROCEDURE

1. Withdraw approximately 10 ml. of blood by veni-puncture or cardiac stab (on anesthetized animals) into a greased, heparinized syringe affixed with a suitable hypodermic needle. Deposit the blood gently in a 15 ml. graduated hematocrit tube containing 0.1 ml. heparin (100 mg. dried heparin dissolved in 15 ml. physiological saline solution.)
2. Centrifuge the blood at 3000 rpm. for 30 minutes. Record the hematocrit.
3. Remove 2 ml. of plasma from the tube and precipitate the plasma proteins: use 1:7 ratio with precipitating reagent (mix 6 ml. of 15 gm. phosphotungstic acid dissolved in 100 ml. of 98% ethyl alcohol with 1 ml. of concentrated hydrochloric acid). Stir for 5 minutes, centrifuge at 3000 rpm. for 5 minutes and pour the supernatant into a Klett tube. Zero the optical density as read on a Klett-Summerson photoelectric colorimeter using a filter with a maximum transmission of light having a wave-length of 622.5 mμ. Refer to this reading as the *blank*.
4. Make-up a *primary* T-1824 dye solution in physiological saline (1 to 4 mg/ml for animals weighing 1 to 100 kg.). Dilute 10 ml. of the primary solution to 100 ml. with distilled water. This serves as the *secondary* dye solution.
5. Add 0.2 ml. of the secondary dye solution to 1.8 ml. of plasma. De-proteinate this solution with the precipitating reagent as described in (3). Record the optical density of this dye *standard* solution (now diluted 100 times) as read on the colorimeter.
6. Wash the red blood corpuscles from (3) with iced, physiological saline solution 3 times and centrifuge at 3000 rpm. for 5 minutes; remove the supernatant with a suction pipette, and discard, after each washing.
7. Add isotonic P-32 solution, containing approximately 50 microcuries of activity, to the red blood corpuscles until the original volume of blood withdrawn in (1) is reached.
8. Incubate this suspension from 1 to 2 hours in a water bath at 37° C. Stir every 10 to 15 minutes with a small, glass rod.
9. Centrifuge the suspension at 3000 rpm. for 5 minutes. Remove and discard the supernatant. Wash the labeled corpuscles 3 times with iced, physiological saline and centrifuge at 3000 rpm. for 5 minutes after each washing; discard the supernatant each time.

10. Add physiological saline solution to the washed and labeled red blood corpuscles until the original volume of blood withdrawn in (1) is reached. Stir the suspension with a small, glass rod. Dilute an aliquot to a known volume with distilled water which serves as the P-32 *standard* solution.
11. Inject 5 ml. of the primary dye solution from (4) and 5 ml. of the labeled corpuscle suspension from (10) into a jugular vein (or other vein depending on the animal). Rinse the syringe 2 or 3 times with blood before removing it from the vein.
12. Withdraw approximately 5 ml. of blood at intervals of 5, 10, and 15 minutes from the opposite (jugular) vein of that into which the injection was made. Use greased, heparinized syringes.
13. Place the withdrawn blood in graduated 15 ml. centrifuge tubes to which heparin has been added as in (1). Centrifuge each sample at 3000 rpm. for 30 minutes and record the hematocrit.
14. Remove the plasma carefully so as not to disturb the red blood corpuscles with a small pipette. Precipitate the plasma proteins of a 2 ml. sample as in (3). Record the optical density of each plasma sample as read on the colorimeter. Calculate the total plasma volume and total blood volume as shown in (18).
15. Wash the red blood corpuscles from (14) according to the procedure in (9).
16. Dilute the labeled corpuscles of each sample to volume with distilled water.
17. Count and record the activity of the P-32 standard and labeled corpuscle samples, singly, using a convenient scaler with an immersion-type Geiger-Muller tube and appropriate aliquots. Calculate the total blood volume and total red cell volume as shown in (19).
18. 
$$V_2 = \frac{100 \times D_1 \times V_1}{D_2}$$

100 = the dilution factor determined in (4) and (5).

$D_1$  = the optical density of the plasma standard dye solution

$D_2$  = the optical density of the plasma sample dye solution

$V_1$  = the volume of the primary dye solution injected

$V_2$  = the total plasma volume

$$^*\text{Hematocrit red corpuscle value} = \frac{\text{red corpuscle volume of hematocrit}}{\text{whole blood volume of hematocrit}}$$

$$\text{Hematocrit plasma value} = (1 - \text{corrected hematocrit red corpuscle value})$$

$$\text{Total blood volume} = \frac{\text{total plasma volume}}{\text{hematocrit plasma value}}$$

19. P-32 calculations:

$$V_2 = \frac{V_1 \times S_1}{S_2}$$

$S_1$  = the counts per minute of the injection dose

$S_2$  = the counts per minute of the blood sample

$V_1$  = the volume of the blood sample

$V_2$  = the total blood volume

$$\text{Red corpuscle volume} = \frac{\text{HRCV} \times 0.915 \times \text{c/m I. D.}}{\text{c/m sample}}$$

HRCV = the hematocrit red corpuscle volume

c/m I. D. = the counts per minute of the injection dose

c/m sample = the counts per minute of the sample

### ACKNOWLEDGMENTS

Appreciation is expressed to Dr. H. B. Sherman, Professor Emeritus, Department of Biology, University of Florida, Gainesville; Dr. Ray L. Shirley, Biochemist, and Dr. George K. Davis, Director, Nutrition Laboratory, University of Florida for their aid and critical evaluations in helping to develop this technique for blood volume determinations. Dr. F. G. Hall, Chairman of the Department of Physiology and Pharmacology, Duke University School of Medicine, Durham, N. C. kindly offered advice and comments on the paper.

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\*Chaplin and Ross (1942) and Mayerson *et. al.* (1948) reported that the amount of plasma trapped between the red blood corpuscles of centrifuged blood is 8.5% of the plasma. Therefore, the hematocrit red corpuscle value should be corrected by multiplying by 0.915.

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## News And Notes

*(Editor's Note: News contributions should be sent to the person whose name appears at the end of the appropriate sections.)*

### MINUTES OF THE FINANCE AND ENDOWMENT COMMITTEE MEETING

Richmond, Virginia — February 20, 1958

The Finance and Endowment Committee met on February 20, 1958, at the Commonwealth Club with the following members present:

Guy Horsley, *Chairman*  
John Forbes  
Edwin Cox  
William Guy

Boyd Harshbarger  
Robert Smart  
Foley Smith  
William Wartman

The chairman distributed copies of the proposed 1958 budget and a report of the estimated 1958 income. He pointed out that the estimated income just about equalled the 1958 budget and, as a consequence, any increase in the budget would require additional income or use of reserve funds.

The treasurer reported that a number of members were upgrading their memberships, most of these being from regular to contributing members.

The chairman expressed the feeling that increasing business memberships was the most likely means of securing additional income. Dr. Forbes suggested that the Academy might consider having a fifty-dollar associate business membership in addition to the regular business membership.

The treasurer distributed copies of the auditor's report of the Academy funds for the two-year period ending December 31, 1957. The estimated cost of this report is three hundred and twenty-five dollars (no statement has been received to date).

The items in the proposed budget were reviewed and the annual meeting expense was raised to seven hundred dollars. This resulted in the budget slightly exceeding the estimated income for 1958.

The chairman read excerpts from a letter from Robert Brumfield, editor of the Journal, in which the steadily rising costs of printing ex-

penses of the Journal were pointed out. This has resulted in the necessity of using reserve Journal funds.

Edwin Cox moved that, subject to approval of Council, the chairman of this committee appoint a subcommittee to raise fifteen hundred dollars during the calendar year. The motion was passed.

It was agreed that Council should be informed at its next meeting of the necessity of the Academy securing additional income.

W. B. Wartman, Jr.

Asst. Secretary

#### AGRICULTURE

Professor Paul M. Reaves, Department of Dairy Science, Virginia Polytechnic Institute received the 1958 Honors Award of the Southern Division, A.D.S.A. at its annual meeting in Little Rock, Arkansas, February 4, 1958. This award was based on Professor Reaves' outstanding contributions to the Dairy Industry of the South.

The second Dairy Science Career Day was held at Virginia Polytechnic Institute on March 3, 1958. This is a part of student recruitment program sponsored by the Virginia Dairy Products Association, the Virginia State Dairymen's Association, the Department of Dairy Science, Virginia Polytechnic Institute. Approximately 100 high school students and 35 industrial leaders who act as sponsors were in attendance.

The National Institute of Health has awarded a four-year research grant to Dr. D. G. Cochran, Associate Professor of Entomology, and Dr. K. W. King, Associate Professor of Bacteriology, to study "Oxidative phosphorylation in insect muscle mitochondria." The grant for the first year is \$7,668.00.

J. A. Schad, Professor of Industrial Arts Education, served as a representative of Virginia Polytechnic Institute on a three-man commission of the Roanoke Chamber of Commerce to study and present data on technical institutes. The report, entitled "A Technical Institute in Roanoke to Serve Western Virginia" was used as a source of information in presenting a proposal for legislative support in the 1958 session of the General Assembly.

Professor of Agricultural Education, Dr. T. J. Horne, is Chairman of the National Research Committee for Agricultural Education. At a recent meeting in Washington, he made a report of progress and participated in planning for an extensive research program in this field.

Carl J. Arnold, Associate Professor in the Department of Agricultural Economics, Virginia Polytechnic Institute has changed from full time extension work in milk marketing to full time research in Agricultural Policy with the Virginia Agricultural Experiment Station.

Dr. A. J. Walrath, Agricultural Economist with the Agricultural Research Service, is now working with the Agricultural Economics Department, Virginia Polytechnic Institute on "Adjustments in land use areas where new employment opportunities are created."

Dr. John McNeill Sieburth, Associate Professor of Bacteriology at the Virginia Polytechnic Institute, has just returned from a visit to the South Pole as a guest of the Argentine Navy. His trip was sponsored by the Arctic Institute of North America, the Virginia Polytechnic Institute, and the Hydrographic Service of the Argentine Navy. He made microbiological studies of Antarctic birds to determine the incidence of diseases transmissible to man and the reasons for previous findings of bacteria free conditions in certain Antarctic birds.

— Carl W. Allen, *Virginia Polytechnic Institute.*

#### BACTERIOLOGY

Dr. E. Clifford Nelson attended the meetings of the American Society of Tropical Medicine and Hygiene of the American Society of Parasitologists in Philadelphia, October 30-November 2, 1957.

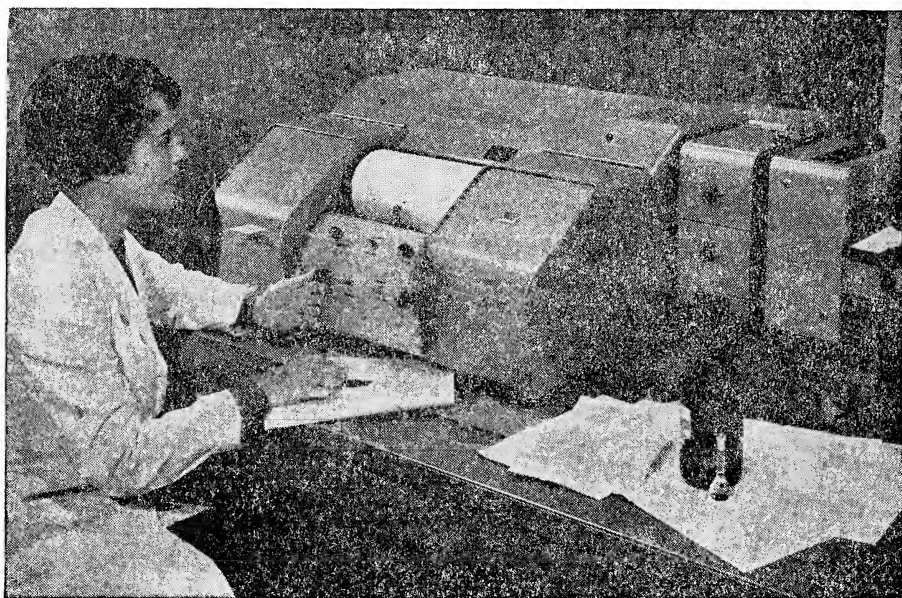
Dr. Holmes T. Knighton, Professor of Dentistry and Bacteriology, attended and participated in the conference of the American Dental Association Council on Dental Therapeutics held in Chicago February 14 and 15.

A paper on the "Influence of Inflammatory Reactions on Localization of Blood-Borne Bacteria" was presented by Dr. Holmes T. Knighton and Dr. George W. Burke at the meeting of the International Association for Dental Research held in Detroit, March 20-22.

—P. Arne Hansen, *Department of Microbiology, University of Maryland*

#### BIOLOGY

A new organization "The Herpetological Society of Virginia" is being formed. All interested persons are asked to contact the Acting Secretary, Franklin Tobey, Route 2, Box 485, McLean, Virginia. Objectives of the society are (1) Scientific study of the Commonwealth's herpetofauna; (2) Improvement in the quality of reporting occurrence of species; (3) Encourage county surveys and exchange of such verified data; (4)



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The Biology Department of the University of Virginia sponsored a rather full program of guest speakers and conferences for the winter and spring, 1958. Among the guest speakers were Dr. John Buck of the National Institutes of Health; Dr. William H. Weston of Harvard; Dr. Caroll Williams of Harvard; Dr. Tom Hall of Washington University; Dr. Nelson Spratt of International Science Foundation; and Dr. Oswald Tippo of Yale University.

Dr. J. D. Burke of the University of Richmond has received a grant from the National Institutes of Health for the purchase of special equipment to continue his study of oxyhaemoglobin in fish.

—Walter S. Flory, Jr., *Blandy Experimental Farm, University of Virginia*

#### CHEMISTRY

The services of Richard M. Irby, Jr., Senior Research Associate for the American Tobacco Company, have been donated to the Richmond school system on a part-time basis. Dr. Irby will teach a twenty-student class at Thomas Jefferson High School in conjunction with Miss Virginia C. Ellett, a member of the high school science faculty. The course will be on a first-year college-level basis and is part of the advanced placement program which prepares students to gain credit and advanced standing in college for work completed in high school.

—Merle A. Kise, *Virginia Smelting Company*

#### ENGINEERING

Professor Frank C. Vilbrandt of the Chemical Engineering Department of Virginia Polytechnic Institute accompanied graduate students of this department on a visit to the DuPont plant at Parkersburg, West Virginia in November. Professor Nelson F. Murphy, also in the Chemical Engineering Department at the Virginia Polytechnic Institute, was co-author of a paper entitled "Correlation of Interfacial Tensions of Three-component Liquid Systems" which appeared in the June issue of *Industrial and Engineering Chemistry*. Dr. Murphy attended the Gordon Research Conference on the application of statistics to chemistry and chemical engineering. In February, he attended the regional meeting of the American Electroplaters' Society in Atlanta, Georgia, serving as chairman

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of one session. Dr. Murphy was one of two inventors to whom a United States patent on a method of electroplating aluminum was issued in September.

Mr. Tilton E. Shelburne, director of the Virginia Council for Highway Investigation and Research at the University of Virginia, in his capacity of District Six Director of the American Society of Civil Engineers, attended a meeting of the Pittsburg Section of this society in January. In January and February, he attended meetings of the Special Technical Advisory Panel on Performance Rating of the AASHO Road Test which were held in Washington and Chicago. Mr. James L. Eades, also of the Virginia Council For Highway Investigation and Research, attended a meeting of the Highway Research Board in Washington in January as a member of the Sub-Committee on Soil Stabilization.

Engineering Dean Lawrence R. Quarles of the University of Virginia has been appointed chairman of the Committee on Advanced Training in Engineering and Applied Science by the Virginia Council on Higher Education. Dean Quarles has announced that all negotiations have been completed for the construction of the one-megawatt nuclear reactor at the University of Virginia. The National Science Foundation awarded a grant of \$150,000 for this reactor and the Atomic Energy Commission provided \$19,000 for instruments for the nuclear laboratory.

Professor Orville R. Harris, Director of the University of Virginia Engineering Experiment Station, and Professor Otis L. Updike of the Chemical Engineering Department of the University attended the Eastern Joint Computer Conference in Washington in December. Dr. Updike was a member of the Local Arrangements Committee for this meeting and is a member of the Steering Committee of the Eastern Simulation Council which was one of the sponsors of this meeting. Professor Robert M. Hubbard of the Chemical Engineering Department of the University of Virginia attended the annual meeting of the American Institute of Chemical Engineers in Chicago in December.

— Robert M. Hubbard, *University of Virginia*

#### GEOLOGY

B. N. Cooper was elected Vice President of the American Association for the Advancement of Science and Chairman of Section E (Geology and Geography) at the meeting of the Association on December 29, 1957.

R. V. Dietrich's paper on "Chromian Muscovite from Baker Mountain, Virginia" appeared in *The American Mineralogist*, 43: (1 and 2),

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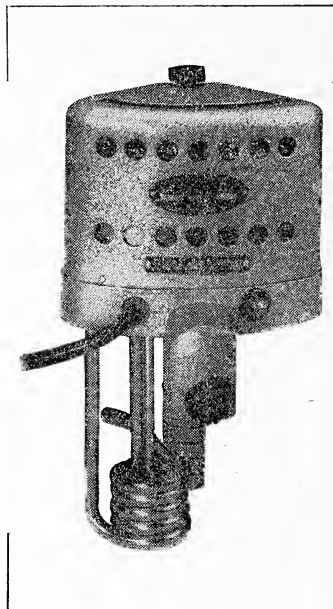
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1958. The second edition of "Virginia Minerals and Rocks" by R. V. Dietrich is now available. It was reprinted as Bulletin 122 of the Virginia Engineering Experiment Station.

James L. Calver and E. O. Gooch attended the annual meeting of the American Institute of Mining, Metallurgical, and Petroleum Engineers held in New York City on February 17-20. Dr. Gooch's paper entitled "Infolded Metasediments Near the Axial Zone of the Catoctin Mountain-Blue Ridge Anticlinorium" is to appear in the April issue of the *Bulletin of the Geological Society of America*.

Donald C. Le Van joined the staff of the Virginia Division of Mineral Resources on December 16, 1957. He received his Bachelor's and Master's Degrees from the University of Michigan. Before joining the staff he was employed by the Pan American Petroleum Corporation. He is married and has one son.

H. R. Hopkins is on educational leave from the Virginia Division of Mineral Resources and is working toward a doctorate in geology. He will return to full-time employment for the summer field season of 1958. Robert S. Wood joined the permanent staff of the Division on August 16, 1957. He received his Bachelor's degree from Washington and Lee University and is doing graduate work at the University of Virginia.

—W. D. Lowry, *Virginia Polytechnic Institute*

#### PSYCHOLOGY

Frank W. Finger is now a representative of the American Psychological Association on the AAAS Council. Richard H. Henneman is representing the Southern Society for Philosophy and Psychology on the AAAS Council.

Richard H. Henneman represented the University of Virginia (in place of Dr. F. A. Geldard, departmental chairman) at a meeting of the heads of departments of psychology granting Ph. D. degrees, which was sponsored by the Southern Regional Education Board and held in Atlanta, December 1-3, 1957.

L. Starling Reid has been appointed a consulting editor of the *Journal of Experimental Psychology*.

Frank A. Geldard has been reappointed to the Divisional Committee on Biology and Medicine of the National Science Foundation.

Hollins College will introduce a co-educational Master of Arts program in the Fall of 1958.

The following speakers are part of the Hollins College Psychology Club program for 1957-58: Fred Keller, B. J. Underwood, Michael Scriven, George Wischner, Carl Frost, Marvin Dunnete, Albert Canfield, Frank Geldard, Murray Sidman, Janet Taylor, and Corbett Thigpen.

*Current Studies in Psychology*, Appleton-Century-Crofts, by F. J. McGuigan and Allen D. Calvin will appear this Spring.

Dr. Cyril Mill recently resigned his position as Clinical Psychologist with the Children's Division of the Allentown, Pennsylvania State Hospital, to accept the position of Chief Clinical Psychologist for the Virginia State Department of Mental Hygiene. He assumed his duties on February 1.

On February 28 the Richmond Psychological Association co-sponsored a panel program entitled "Modern Approaches to the Retarded Child." Included in the panel was Robert Gibby, Chief Clinical Psychologist, McGuire VA Hospital. William L. Dunn, Jr., Vice-President of the Richmond Psychological Association, served as moderator.

—John K. Bare, *College of William and Mary*

#### STATISTICS

Prof. Boyd Harshbarger attended the AAAS meetings in Indianapolis where he presided over the session on the Relation between Smoking and Lung Cancer. The speaker for this occasion was Sir Ronald A. Fisher, Cambridge, England. The session was attended by over 700.

Dr. Herbert A. David is now with the Department of Statistics at the Virginia Polytechnic Institute. Dr. David was born in Berlin and attended schools in Dusseldorf, Germany and Sydney, Australia. He received the B.Sc. in mathematics from the University of Sydney and the Ph.D. in statistics from the University of London. He was senior lecturer at the University of Australia prior to his joining the Department of Statistics at the Virginia Polytechnic Institute. He has written a number of papers on mathematical and applied statistics, many of which were published in *Biometrika*.

Dr. Rolf Bargmann joined the Department of Statistics at the Virginia Polytechnic Institute in January. He was born in Germany and received his formal education from the University of Berlin, University of Hamburg, University of Chicago, and completed the requirements for the doctorate at the University of North Carolina in December 1957. Dr. Bargmann's duties have included working as a designer of radio equipment and chemist; part-time instructor for physics, mathematics,

and English at Hamburg; court interpreter for English and German at the Nuernberg Trials; "Textbook Analyst" for the evaluation of German textbooks in mathematics, science, and foreign languages; Consultant for Educational Research; Research Assistant, Assistant Professor and Chief of Statistical Department, Hochschule fuer Internationale Paedagogische Forschung, Frankfurt, Germany.

Norbert Lloyd Enrick, Head of Statistics, Institute of Textile Technology, Charlottesville, Virginia, attended the convention of Committee D-13 of the American Society for Testing Materials, Subcommittee B-8, to continue his work with the Task Group on Electronic Yarn Imperfection Counters; and to work further with Subcommittee B-5 in preparing an ASTM manual of statistical methods for textile technologists.

—Clyde Y. Kramer, *Virginia Polytechnic Institute*



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ASHLEY ROBEY (Roanoke College) and MISS LESLIE WATKINS, *Junior Academy Exhibits*  
H. L. HOLLOWAY (Roanoke College), N. F. MURPHY (Virginia Polytechnic Institute), and R. W. ENGLE (Virginia Polytechnic Institute), *Registration*  
R. E. GARRETT (Hollins College) and MISS LESLIE WATKINS, *Public Information*  
N. F. MURPHY (Virginia Polytechnic Institute), J. D. SCHUMACHER

(American Viscose Corporation, B. W. MAHONEY (General Electric Company) and G. V. DOWNING (Leas and McVitty, Inc.), *Commercial Exhibits*

P. R. THOMSON (General Electric Company), B. M. SMITH (Veterans Administration Hospital), and R. A. CRAIGHEAD (Norfolk and Western Railway Company), *Industrial Tours*.

MRS. RUTH PAINTER (William Fleming High School), MRS. ATHENA BURTON (Roanoke College), and DOROTHY D. MONTGOMERY (Hollins College), *Entertainment for Ladies*

### HOSTS TO MEETING

HOLLINS COLLEGE

ROANOKE COLLEGE

VIRGINIA POLYTECHNIC INSTITUTE

AMERICAN VISCOSE CORPORATION

GENERAL ELECTRIC COMPANY

NORFOLK AND WESTERN RAILWAY COMPANY

VETERANS ADMINISTRATION HOSPITAL

## General Program Of The 36th Annual Meeting

*All meetings, unless otherwise indicated, will be held at the Hotel Roanoke, Roanoke, Virginia*

### EXHIBITORS. PEACOCK ALLEY

#### WEDNESDAY, MAY 7

5:00 P.M. to 10:00 P.M.—Registration for Junior Academy Members and Participants in the Science Talent Search. Colonial Room.

5:00 P.M. to 10:00 P.M.—Arrangement of Exhibits. Exhibit Room (in basement).

## THURSDAY, MAY 8

- 8:00 A.M. to 10:00 P.M.—Registration. Colonial Room.
- 9:00 A.M.—Meeting of Science Exhibit Judges. Parlor L.  
Meeting of Science Talent Search Judges. Parlor K.
- 9:30 A.M.—Meeting of Chairmen, Exhibitors, and Science Talent Search Participants, Shenandoah Room.
- 10:00 A.M. to 12:30 P.M. and 1:30 to 4:00 P.M.—Finalists of Talent Search Meet with Chairmen and Interviewers. Parlors E, F, K, and L.
- 10:00 A.M. to 12:30 P.M. and 1:30 to 4:00 P.M.—Judging of Science Exhibit Contest. (Encouragement of Juniors at their Exhibits.) Exhibit Room.
- 2:00 P.M.—Meeting of the Council. Parlor D.
- 4:00 P.M.—Meeting of Section Officers, Pocahontas Room.  
Meeting of Junior Academy of Science Committee. Parlor L.
- 4:30 P.M.—Meeting of Section Editors. Cavalier Room.
- 8:00 P.M.—Annual Academy Conference. Ballroom.

## FRIDAY, MAY 9

- 8:30 A.M. to 10:00 P.M.—Registration. Colonial Room.



- 9:00 A.M.—Section Meetings. See the detailed section programs for the time schedule of papers.  
*Agricultural Science* — Auditorium, St. Andrews School  
*Astronomy, Mathematics, and Physics* — Parlor D  
*Bacteriology* — Parlor L.  
*Biology* — Shenandoah Room  
*Chemistry* — Ballroom  
*Education* — Parlor K  
*Engineering* — Parlor E  
*Geology* — Parlor F  
*Medical Sciences* — Cavalier Room  
*Psychology* — Pocahontas Room  
*Science Teachers* — Pine Room  
*Statistics* — Writing Room
- 12:00 Noon to 2:00 P.M.—Virginia Junior Academy of Science Assembly. Ballroom. (See Program of Junior Academy.)
- 1:00 P.M. to 2:00 P.M.—Recess for Luncheon.
- 2:00 P.M.—Section Meetings.
- 4:00 P.M. to 5:00 P.M.—Informal Tea and Fashion Show for Visiting Ladies. Laurel Room — Heironimus of Roanoke.
- 5:00 P.M. to 7:45 P.M.—Recess for Dinner.
- 7:45 P.M.—Virginia Academy of Science Assembly. Ballroom.  
Welcome from Hosts to the Meeting by Boyd Harshbarger.  
Short Business Meeting. Election of Officers. Presentation of  
Presentation of the J. Shelton Horsley Research Award.  
*Guest Speaker*: Dr. Laurence H. Snyder, Dean of the Graduate College, University of Oklahoma, and Immediate Past President of the American Association for the Advancement of Science.  
*Subject*: Heredity in Human Health and Disease.  
The general public is invited to attend.

## SATURDAY, MAY 10

- 9:00 A.M.—Section Meetings.
- 10:00 A.M.—Meeting of the Council of the Academy. Parlor D.

## Program Of The Virginia Junior Academy Of Science

*All meetings will be held at the Hotel Roanoke,  
Roanoke, Virginia*

### WEDNESDAY, MAY 7

5:00 P.M. to 10:00 P.M. — Registration for Junior Academy Members and participants in the Science Talent Search. Colonial Room

5:00 P.M. to 10:00 P.M. — Arrangement of Exhibits. Exhibit Room (basement)

### THURSDAY, MAY 8

8:00 A.M. to 10:00 P.M. — Registration. Colonial Room

9:00 A.M. to 9:30 A.M. — Meeting of Science Exhibit Judges. Parlor L  
Meeting of Talent Search Judges. Parlor K

9:30 A.M. to 10:00 A.M. — Meeting of Chairmen, Exhibitors, and Science Talent Search Participants. Shenandoah Room

10:00 A.M. to 12:00 P.M. — and 1:00 P.M. to 3:00 P.M. — Finalists of Talent Search meet with Chairmen and Interviewers. Parlors E, F, K, and L

10:00 A.M. to 12:00 P.M. — and 1:00 P.M. to 3:00 P.M. — Judging of Science Exhibit Contest. Exhibit Room

3:00 P.M. — Business Meeting of Virginia Junior Academy of Science. Parlor L

8:00 P.M. — Discussion Hour: Junior Academy Members and Invited Scientists.

### FRIDAY, MAY 9

9:00 A.M. — Participation in the Senior Academy Section Meetings.

12:00 Noon to 2:00 P.M. — Virginia Academy of Science Assembly and Awards Hour. Ballroom

*Guest Speaker:* To be announced.

## Section Of Agricultural Science

James W. Midyette, Jr., *Chairman*

Allen H. Allison, *Vice-Chairman*

S. S. Obenshain, *Secretary*

C. W. Allen, *Section Editor*

FRIDAY, MAY 9—8:30 A.M.—AUDITORIUM, ST. ANDREWS SCHOOL

1. 8:30 Call to order by Chairman. Announcements and Committee Appointments.
2. 8:40 Available Calcium and Magnesium in Soils of Varying Texture.  
W. W. Moschler; *Virginia Agricultural Experiment Station*
3. 8:55 The Affect of Initial Weight and Age upon the Molybdenum Induced Rat Growth.  
Lynn Brinkman and R. F. Miller; *Virginia Agricultural Experiment Station*
4. 9:10 The Effect of Twelve Essential Elements Sprayed on Virginia Type Runner Peanuts at Flowering Stage.  
D. L. Hallock; *Virginia Agricultural Experiment Station*
5. 9:25 Shift in Nitrogen Metabolism during the Life of a Cell.  
R. R. Schmidt, R. W. Krauss, and K. W. King; *Virginia Agricultural Experiment Station*
6. 9:40 The Effects of Gonadotropins and other Hormones on the Various Reproductive Phenomena of the Ewe.  
J. W. Gossett, B. Baker, P. P. Grayson, C. S. Givens, Jr., and R. C. Carter; *Virginia Agricultural Experiment Station*
- 9:55 Recess
7. 10:05 The Effect of Calcium, Phosphorus, and Copper upon the Growth of the Rat.  
R. F. Miller; *Virginia Agricultural Experiment Station*
8. 10:20 New Crop Pests Threatening Virginia.  
C. R. Willey; *Department of Agriculture and Immigration*
9. 10:35 The Use of Tetrazolium to Evaluate the Viability of Seed Peanuts.

H. L. Smith and T. G. Copeland; *Virginia Department of Agriculture*

10. 10:50 Regulating Fertilizer Pesticides Mixtures.  
Maurice B. Rowe, III; *Virginia Department of Agriculture*
11. 11:05 *Guest Speaker*: R. W. Engel, *Virginia Agricultural Experiment Station*  
*Subject*: Higher Education in the Sciences in Virginia.
12. 11:35 Resources Needed in Virginia Agriculture in the Decade Ahead.  
C. W. Allen; *Virginia Agricultural Experiment Station*
- 11:50 Adjourn for Lunch.
13. 1:15 Use of Infra-Red for Conducting Regulatory Chemical Analyses.  
Boyd L. Samuel; *Virginia Department of Agriculture*
14. 1:30 *Guest Speaker*: V. H. Young, Jr., *Merck & Co., Inc.*  
*Subject*: History and Potential Use of Gibberellic Acid.
15. 2:00 Effect of Amino Acids in the Ration and Growth Pattern on Muscle Development In Swine.  
C. C. Brooks and H. R. Thomas; *Virginia Polytechnic Institute*
16. 2:15 Checking Variety Claims on Oats, Barley and Soybeans by Laboratory And Field Tests.  
Harry Smith, Graham Copeland, and J. W. Midyette, Jr.; *Virginia Department of Agriculture and Immigration*
17. 2:30 The Influence of Age, Sex and Season of Birth of Calf, and Age of Cow on Prewaning Growth Rate and Type Score of Beef Calves.  
T. J. Marlowe, and J. A. Gaines; *Virginia Agricultural Experiment Station*
- 2:45 Recess
18. 2:55 Use of Soil Type in Appraisal Work in Fairfax County, Virginia.  
C. S. Coleman; *Virginia Agricultural Experiment Station*
19. 3:10 Some Factors affecting the Optical Density of Acetone Extracts of Fresh Feces.  
C. G. Noblitt and W. A. Hardison; *Virginia Agricultural Experiment Station*

20. 3:25 Cost of Packing Apples in Bushel Units as affected by Different Types of Equipment and the Scale of Operation.  
Albert W. Graybill; *Virginia Agricultural Experiment Station*
21. 3:40 Effect of Lime on the Mineral Composition of Soybean Foliage.  
N. O. Price, W. W. Moschler, and W. Kroontje; *Virginia Agricultural Experiment Station*
- 3:45 Business Session

## Section of Astronomy, Mathematics and Physics

E. R. Dyer, Jr., *Chairman*

J. J. Taylor, *Secretary*

I. G. Foster, *Section Editor*

FRIDAY, MAY 9 — 9:00 A.M. — PARLOR D

9:00 Announcements

1. 9:10 Design and Evaluation of a Cadmium Shield on the Virginia Polytechnic Institute Exponential Pile.  
A. DeVolpi and A. Robeson; *Virginia Polytechnic Institute*
2. 9:25 A Versatile, Flexible Control Rod for Sub-Critical Systems.  
J. E. Kinzer and A. Robeson; *Virginia Polytechnic Institute*
3. 9:40 A Graphite Sigma-Pile for the Measurement of Moderate Parameters.  
L. S. Anthony and A. Robeson; *Virginia Polytechnic Institute*
4. 9:55 The Vibrations of a Loaded Cantilever.  
I. G. Foster; *Virginia Military Institute*
5. 10:10 Measurements of Compressibilities of Solidified Gases at Various Low Temperatures.  
John W. Stewart and Ralph I. LaRock; *University of Virginia*
6. 10:30 Experimental Determination of the Densities of Several Solidified Gases at 77°K.  
Ralph I. LaRock and John W. Stewart; *University of Virginia*.

7. 10:45 Rolling Polygons.  
Robert C. Yates; *College of William and Mary*
8. 11:05 Colors, Magnitudes and Motions of Stars of Spectral Class R.  
Gordon L. Vandervort; *University of Virginia* (Introduced by  
A. N. Vyssotsky)
9. 11:20 A Search for Distant Blue Stars in High Galactic Latitudes,  
Charles R. Cowley; *University of Virginia* (Introduced by  
A. N. Vyssotsky)
10. 11:35 The Richmond Area Seminar for High School Mathematics  
Teachers.  
E. Sherman Grable; *University of Richmond*
- 11:50 Business Meeting
- 12:00—2:00 Lunch and Junior Academy Program
11. 2:00 Long-Enduring Meteor Trains and Fireball Orbits (Third  
Paper).  
Charles P. Olivier; *University of Pennsylvania*
12. 2:15 An Undergraduate Laboratory Course in Nuclear Physics.  
Frederick R. Crownfield, Jr.; *College of William and Mary*
13. 2:30 Some Gamma Ray Experiments for an Undergraduate Course  
in Nuclear Physics.  
E. T. Gerry and F. R. Crownfield, Jr.; *College of William and  
Mary*
14. 2:45 Experiments with the Ballistics of a Rifle Bullet.  
S. Topp; *College of William and Mary* (Introduced by F. R.  
Crownfield)
15. 3:00 Design and Construction of a Long Lens Beta Ray Spectro-  
meter.  
J. W. Little and J. F. Roach; *College of William and Mary*  
(Introduced by F. R. Crownfield, Jr.)
16. 3:15 Comments on Magnetic Thin Films.  
G. Wayne Clark; *Virginia Institute for Scientific Research*
17. 3:30 Hysteresis Loop Tracer for Magnetic Thin Films.  
B. W. Sloope; *University of Richmond* (work done at Virginia  
Institute for Scientific Research).
18. 3:45 Magnetic Domains of Thin Films by the Kerr Magneto-Optic  
Effect.

Calvin O. Tiller; *Virginia Institute for Scientific Research*

19. 4:00 Coercive Force *vs.* Thickness for Thin Films of Nickel-Iron  
Calvin O. Tiller and G. Wayne Clark; *Virginia Institute for Scientific Research*
20. 4:15 What Should We Do about Centrifugal Force and Earth Satellites?  
B. W. Sloope; *University of Richmond*

SATURDAY, MAY 10

9:00 Announcements

21. 9:05 Pharmatomity — Atoms for Peace.  
Mrs. Agnes K. Beall; *Rutgers University* (Introduced by Miss Elinor Wayne)
22. 9:25 The Quantum Theoretical Concept of Measurement.  
John L. McKnight; *College of William and Mary*
23. 9:50 Millimicrosecond Pulse Amplifiers.  
W. T. Joyner; *Hampden-Sydney College* (Introduced by T. E. Gilmer)
24. 10:05 A Relaxed Condition on the Existence Theorem for Simultaneous Implicit Functions.  
Reuben R. McDaniel; *Virginia State College*
25. 10:20 A Further Study on Newton's Interference Patterns from Coated Surfaces.  
H. Y. Loh; *Virginia Polytechnic Institute*
26. 10:35 On the Mechanical Properties of Whiskers of Hexagonal Metals.  
P. B. Price and M. J. Skove; *University of Virginia*
27. 10:50 The Effect of High Strain and Low Temperature on the Resistivity of Metal Whiskers.  
Herman H. Hobbs and E. P. Stillwell, Jr.; *University of Virginia*
28. 11:05 Photodisintegration of Light Nuclei.  
P. Flournoy, R. S. Tickle, and W. D. Whitehead; *University of Virginia*
29. 11:20 The  $Al^{27}(\gamma, 2p) Na^{25}$  to 65 Mev.  
L. B. Aull and W. D. Whitehead; *University of Virginia*
- 11:50 Announcements and Adjournment

## Section of Bacteriology

Mrs. Barbara H. Caminita, *President*

Miles E. Hench, *Vice-President*

Quentin N. Myrvik, *Secretary-Treasurer*

P. Arne Hansen, *Section Editor*

FRIDAY, MAY 9 — 11:00 A.M. — PARLOR L

### 11:00 Business Meeting

1. 2:00 Serum Bactericidin Levels for *Bacillus subtilis* in Human Malignancies.  
H. C. Alexander and Eva Soto-Figueroa; *Department of Microbiology, University of Virginia School of Medicine*
2. 2:15 Rapid Detection of *Salmonella typhosa* by Fluorescent Antibody Technique.  
Walter R. Dowdle, Charles T. Hall and P. Arne Hansen; *Department of Microbiology, University of Maryland*
3. 2:30 Studies on Human Tissue Antigens.  
Gerald Goldstein and Quentin N. Myrvik; *Department of Microbiology, University of Virginia School of Medicine*
4. 2:45 A Serological and Physiological Study of Heterofermentative Lactobacilli.  
Anne Zerschling and P. Arne Hansen; *Department of Microbiology, University of Maryland*
5. 3:00 Lysis of Modified Erythrocytes by Normal Serum.  
H. J. Welshimer and Nancy G. Winglewish; *Department of Microbiology, Medical College of Virginia*
6. 3:15 Methods for Revealing Ingested Bacteria in *Entamoeba histolytica*.  
E. Clifford Nelson; *Department of Microbiology, Medical College of Virginia*
7. 3:30 A Microbiological Study of Antarctic Birds.  
John McNeill Sieburth; *Virginia Polytechnic Institute*



## Section of Biology

William J. Hargis, Jr.; *Chairman*

Bertram L. Hanna, *Secretary*

Walter S. Flory, Jr.; *Section Editor*

### FRIDAY, MAY 9 — 9:00 A.M. SHENANDOAH ROOM

1. 9:00 Compatability Relationships in the Convolvulaceae.  
R. J. Knight; *The Blandy Experimental Farm*
2. 9:15 Preliminary Studies of Cavernicolous Fungi.  
William W. Scott and Margaret M. Holland; *Virginia Polytechnic Institute*
3. 9:30 The Saga of Virginia's Water Lily.  
Agnes K. Beall and Elinor T. Wayne; *Rutgers University and Madison College*
4. 9:45 A Comparative Study of the Phallic Papilla of Four Genera of Crayfishes of the Family Astacidae.  
Thomas L. Johnson; *University of Virginia*
5. 10:00 Wildlife in the Pre-colonial Period.  
John H. Reeves; *Virginia Polytechnic Institute*
6. 10:15 Host Specificity and *Odostomia impressa*, Say.  
J. Frances Allen; *University of Maryland*
7. 10:30 General Considerations in Laboratory Animal Care.  
Berton F. Hill; *Executive Secretary, Institute of Laboratory Animal Resources; National Academy of Sciences* (by invitation)
8. 11:15 Salinity and Oxy-hemoglobin Affinity.  
Jack D. Burke; *University of Richmond*
9. 11:30 The Effect of Ultra-violet and X-radiation on the Growth of *Phleum pratense* roots.  
Robert T. Brumfield; *Longwood College*
10. 11:45 Preliminary Studies on the Effects of Potassium Gibberellate on Growth Phases of Mosses.  
Paul M. Patterson; *Hollins College*
11. 12:00 Cytological Studies in *Setcreasea purpurea* Boom and *S. brevifolia* (Torr.) Rose

Smritimoy Bose; *The Blandy Experimental Farm, University of Virginia*

12. 12:15 Selection of the Large Milkweed Bug for Resistance to Insecticides.  
James McDonald Grayson; *Virginia Polytechnic Institute*
13. 12:30 Seasonal Influences on Certain Features of the Anatomy of the Skin of Sheep and Goats.  
Lubow A. Margolena; *United States Department of Agriculture, Beltsville, Maryland*
- 12:45 Section Business Meeting
14. 2:15 Short-Term Survival in Pen-reared Quail.  
Thomas H. Ripley and Russell A. Cookingham; *Virginia Polytechnic Institute*
15. 2:15 Intraspecific Variations in the White Perch, *Roccus americanus* (Gmelin).  
William S. Woolcott; *University of Richmond*
16. 2:30 To be announced.  
Donald L. McKernan, Director, Bureau of Commercial Fisheries; U. S. Game and Wildlife Service (by invitation)
17. 3:15 The Exoskeleton of a Freshwater Crab as a Microhabitat for Several Invertebrates.  
Horton H. Hobbs, Jr. and Alejandro Villalobos; *University of Virginia*
18. 3:30 Native Shrubs of Virginia.  
Arthur L. Eiser; *Virginia Polytechnic Institute*
19. 3:45 Grasses of Virginia.  
A. B. Massey; *Virginia Polytechnic Institute*
20. 4:00 Studies on Evolutionary Divergence of the Floras of Southeast Asia and the Southeastern United States.  
Mary Jo Parrish; *Mary Washington College*
21. 4:15 Blood Oxygen Capacity in Frogs.  
Frank Leftwich; *University of Richmond*
22. 4:30 A Preliminary Survey of the Ciliated Protozoa from Tree Borne Mosses and Lichens in the Mountain Lake Area.  
Jesse C. Thompson, Jr.; *Hollins College*
23. 4:45 Chromosome Sequence Change and in Inversion Bridge in *Rhoeo discolor*.  
R. O. Flagg; *University of Virginia*

## Section of Chemistry

Joe C. Holmes, *Chairman*

Frank A. Vingiello, *Secretary*

Merle A. Kise, *Section Editor*

FRIDAY, MAY 9, — 9:00 A.M. — BALLROOM

9:00 Announcements; Introductory Remarks

1. 9:15 Neutron Diffraction Observations on the Palladium-Hydrogen and Palladium-Deuterium Systems.  
James E. Worsham, Jr., M. K. Wilkinson and C. G. Shull;  
*University of Richmond, Oak Ridge National Laboratory and the Massachusetts Institute of Technology*
2. 9:30 Aggregation Studies of Soybean Protein.  
Carl J. Likes; *Virginia Institute for Scientific Research*
3. 9:45 The Use of Low Voltage Mass Spectroscopy in Qualitative Analysis of Organic Compounds.  
Charles Varsel, Francis A. Morrell, Frank E. Resnick, and W. Allan Powell; *Philip Morris, Inc., and the University of Richmond*
4. 10:00 The Use of Infrared Spectrophotometry in the Analysis of Piperazine Salts.  
William R. Maynard, Jr.; *Division of Chemistry and Foods, Virginia Department of Agriculture*
5. 10:15 A Rapid Spectrophotometric Determining of Total Alkaloids in Tobacco Smoke.  
Charlotte Haynes and Sylvester Pleasants; *Philip Morris, Inc.*
- 10:30 Recess
6. 10:45 Spectrochemical Determination of Certain Trace Elements in Human Plasma and Red Cells.  
Leonel M. Paixao and John H. Yoe; *Pratt Trace Analysis Laboratory, Department of Chemistry, University of Virginia*
7. 11:00 Spectrophotometric Determination of Chromium in Human Plasma And Red Cells.  
Dwight O. Miller; *Pratt Trace Analysis Laboratory, Department of Chemistry, University of Virginia*

8. 11:15 Some Derivatives of Dithiooxamide as Reagents for the Simultaneous Spectrophotometric Determination of Traces of Cobalt, Nickel and Copper.  
William D. Jacobs; *Pratt Trace Analysis Laboratory, Department of Chemistry, University of Virginia*
9. 11:30 Spectrophotometric Determination of Aluminum with Quinizarin -2,3-Disulfonic Acid Na-Salt.  
E. Guy, Owens, II and John H. Yoe; *Pratt Trace Analysis Laboratory, Department of Chemistry, University of Virginia*
10. 11:45 Spectrophotometric Determination of Uranium with 3- (2-Arsonophenzlazo) -4,5-Dihydroxy - 2, 7- Naphth-a-lenedisulfonic Acid (Trisodium Salt).  
H. Perry Holcomb and John H. Yoe; *Pratt Trace Analysis Laboratory, Department of Chemistry, University of Virginia*
- 12:00 Business Meeting
11. 2:00 Reaction of Ethylene Oxide with Histidine, Methionine and Nicotinic Acid.  
H. G. Windmueller and C. J. Ackerman; *Department of Biochemistry and Nutrition, Virginia Polytechnic Institute*
12. 2:15 Imide and Hydrazone Plant Hormones.  
Lowell V. Heisey; *Department of Chemistry, Bridgewater College*
13. 2:30 Aromatic Cyclodehydration on Solid Surfaces.  
Frank A. Vingiello and Martin Sprangler; *Department of Chemistry, Virginia Polytechnic Institute*
14. 2:45 Preparation of Some Cyclic Sulfones from 1,3-Pentadiene.  
Robert C. Krug and James A. Rigney; *Department of Chemistry, Virginia Polytechnic Institute*
15. 3:00 Physical Properties of Systems of Toluene and Water Containing Glycol Ethers.  
Newton C. Landis and Nelson F. Murphy; *Department of Chemical Engineering, Virginia Polytechnic Institute*
16. 3:15 Kinetics of the Acid Catalyzed Cyclization of o-Benzylbenzophenone in Acetic Acid-Water Mixtures.  
L. K. Brice, Jr. and R. D. Katstra; *Department of Chemistry, Virginia Polytechnic Institute*
17. 3:30 The Acid Catalyzed Depolymerization of Trioxane in Concentrated Hydrochloric Acid Solutions. Salt Effects and Correla-

tion with Ho.

L. K. Brice, Jr. and L. P. Lindsay; *Department of Chemistry, Virginia Polytechnic Institute*

18. 3:45 The Heat of Sublimation of Boron and the Gaseous Species of the Boron-Boric Oxide System.  
Alan W. Searcy and Clifford E. Myers; *Department of Chemistry, Lynchburg College*
19. 4:00 Surface Rearrangements Produced on a Copper Monocrystal by the Catalytic Reaction of Hydrogen and Oxygen.  
Richard Y. Meelheim; *Department of Chemistry, University of Virginia.*
20. 4:15 Corrosion Inhibition and Activation of Iron and other Metals by Metallic Cations in Fruit and Mineral Acids.  
Roger Buck; *Virginia Institute for Scientific Research*
21. 4:30 An Unusual Elbs — Type Reaction Observed during a Study of the Cyclization of Ketones.  
Frank A. Vingiello, Alexej Borkovec and Walter Zajac, Jr.,  
*Department of Chemistry, Virginia Polytechnic Institute*

## Section of Education

Evan G. Pattishall, *Chairman*

Charles Turner, *Secretary*

James B. Patton, Jr.; *Section Editor*

FRIDAY, MAY 9 — 9:00 A.M. — PARLOR K

1. 8:30 Registration
2. 9:00 The Conservation Knowledge of Virginia School Pupils.  
Robert H. Giles, Jr.; *Virginia Commission of Game and Inland Fisheries*
3. 9:25 Some Characteristics of Youth Enrolled in an Institution for the Hard of Hearing.  
Alonzo M. Myster; *Virginia State College*
4. 9:50 Validation of the Wert-Myster Farming Attitude Scale in a Group of High School Pupils in Virginia.  
Alonzo M. Myster; *Virginia State College*

5. 10:15 Recess
6. 10:30 Development of Interests in Elementary School as Studied by a Pictorial Interest Schedule.  
Shelva Dove and George W. Kent; *Bridgewater College*
7. 10:55 The Prediction of Academic Achievement in College by a Motivation Index.  
Norman Rebert and George W. Kent; *Bridgewater College*
8. 11:20 A Word-Color Association Test.  
Harry S. Beck; *University of Virginia*
9. 11:45 The Application of Operations Research to Educational Problems.  
John M. Long; *University of Virginia*
10. 12:10 What Becomes of Boys Who Study Vocational Agriculture in the High School?  
H. W. Sanders; *Virginia Polytechnic Institute*
11. 12:35 The Human Governor: Cybernetics and Communication Theory.  
David Redfield; *University of Virginia*
12. 1:00 Business Meeting and Election of Officers
13. 1:30 Adjournment

## Section of Engineering

Otis L. Updike, Jr.; *Chairman*

Arthur C. Bruce, *Secretary*

Robert M. Hubbard, *Section Editor*

FRIDAY, MAY 9 — 9:10 A.M. — PARLOR E

1. 9:10 Aerodynamic Characteristics of a Hemisphere in Newtonian Flow.  
E. Brian Pritchard; *Virginia Polytechnic Institute*
2. 9:30 Characteristics of Complete Aircraft Configurations at Hypersonic Speeds.  
Robert W. Truitt and William Grossmann; *Virginia Polytechnic Institute*
3. 9:50 Minimum-Dray Configurations at Hypersonic Speeds.

Robert W. Truitt and Thomas H. Thornton, *Virginia Polytechnic Institute*

4. 10:10 Longitudinal Stability Derivatives of Missile-Shaped Bodies at Hypersonic Speeds.  
Robert H. Tolson and James B. Eades, Jr.; *Virginia Polytechnic Institute*
5. 10:30 Some Aspects of Magnetohydrodynamics.  
Robert W. Truitt and Richard D. Wagner; *Virginia Polytechnic Institute*
6. 10:50 Aeronautical Applications of Magnetohydrodynamics.  
Robert W. Truitt and Norris E. Mitchell; *Virginia Polytechnic Institute*
7. 11:10 The Effect of Heat Insulation on the Internal Cooling Requirements of High Speed Vehicles.  
John N. Perkins; *Virginia Polytechnic Institute*
8. 11:30 Joining Aluminum with High Zinc Solders by Abrasion.  
O. R. Singleton, Jr.; *Metallurgical Research Laboratory, Reynolds Metal Company, Richmond, Virginia.*
- 12:00 Presentation of Engineering Award at the meeting of the Junior Academy of Science.
9. 2:00 Drag Reduction by Blunting.  
Robert W. Truitt and Clairborne R. Hicks; *Virginia Polytechnic Institute*
10. 2:20 A Correlation for Drag Coefficient at Transonic Speeds -- Axially Symmetric Flow.  
James B. Eades, Jr.; *Virginia Polytechnic Institute*
11. 2:40 A Comparison of the Rate of Heat Transfer through Flat Plates and Cylindrical Shells.  
Samuel C. Wilson and John N. Perkins; *Virginia Polytechnic Institute*
12. 3:00 Minimum-Drag Bodies in the Superaerodynamic Region.  
Robert W. Truitt and C. Howard Robins; *Virginia Polytechnic Institute*
13. 3:20 Artificial Satellite Spiral Descent Mechanics.  
James T. McDaniel and A. C. Bruce; *Virginia Polytechnic Institute*
14. 3:40 Vehicle Mechanics in an Earth-Moon Gravity Field.

John W. Barnes and A. C. Bruce; *Virginia Polytechnic Institute*

15. 4:00 Escape Trajectory for a Vehicle in the Earth-Moon Gravity Field.  
Lester W. Roane and A. C. Bruce; *Virginia Polytechnic Institute*
16. 4:20 Engineering Exhibits.  
Presented by Members of the Virginia Junior Academy of Science.
- 5:20 Business Meeting and Election of Officers.

SATURDAY, MAY 10 — 9:00 A.M.

17. 9:00 Decolorization of Caustic Wash Liquors From Chlorine-Bleached, Sulfate Wood Pulp.  
Peter W. Ruggieri, Jr. and N. F. Murphy; *Virginia Polytechnic Institute*
18. 9:15 Overall Mass Transfer Coefficients for a Homologous Series of Poly-Glyco IETHERs between Toluene and Water.  
Robert H. Pusey and N. F. Murphy; *Virginia Polytechnic Institute*
19. 9:30 Studied in Absorption using Molecular Sieves.  
C. R. Price, P. H. Terry and F. W. Bull; *Virginia Polytechnic Institute*
20. 9:45 A Continuous Countercurrent Absorber for Instructional Purposes.  
S. A. Burnette, J. S. Chowning and F. W. Bull; *Virginia Polytechnic Institute*
21. 10:10 Evaluation of Factors Affecting the Extraction Efficiency of an Experimental Pulse, Liquid-Liquid Extractor.  
D. L. Merrill, R. M. McEachern, R. E. Wood and F. W. Bull; *Virginia Polytechnic Institute*
22. 10:15 True Averaging, Non-Saturating Electro-Pneumatic Conversion.  
Walter P. Walker and Henry R. Blane; *University of Virginia Engineering Experiment Station*
23. 10:30 Research on Focusers for Molecular Oscillators.  
Kenneth L. Haynes, R. L. Ramsey and O. R. Harris; *University of Virginia Engineering Experiment Station*



24. 10:50 Evaluation of High Temperature Antioxidants.  
Dennis M. Frame and James W. Cole, Jr.; *University of Virginia*
25. 11:10 Application of Analog Computing Equipment to Extraction Calculations.  
Patricio Castro and Otis L. Updike; *University of Virginia*
26. 11:30 Mechanisms of the Low Pressure Polymerization for Ethylene to Polyethylene.  
Y. K. Pan and Frank C. Vilbrandt; *Virginia Polytechnic Institute*
27. 11:40 The Separation of a Hydrogen-Carbon Dioxide Mixture by Gaseous Diffusion.  
Russell A. Primrose and Frank C. Vilbrandt; *Virginia Polytechnic Institute*
28. 11:55 Mechanisms by which Ultrasonics Energy Affects Transfer Rates in Liquid-Liquid Extraction.  
Hughey A. Woodle and Frank C. Vilbrandt; *E. I. du Pont de Nemours and Company* and *Virginia Polytechnic Institute*

## Section of Geology

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J. T. Hack, *Vice-Chairman*

R. S. Mitchell, *Secretary*

W. D. Lowry, *Section Editor*

FRIDAY, MAY 9 — 9:00 A.M. — PARLOR F

9:00 Announcements

1. 9:10 What is "Basement Complex" in Virginia?  
C. E. Sears; *Virginia Polytechnic Institute*
2. 9:30 Silurian of Virginia: A Review.  
C. G. Tillman; *Virginia Polytechnic Institute*
3. 9:50 The Geomorphic Significance of Residual and Alluvial Deposits in the Shenandoah Valley, Virginia.  
J. T. Hack; *United States Geological Survey*
4. 10:10 A Further Discussion of the Saltville Fault in Smyth and

Washington Counties, Virginia.

W. A. Nelson; *University of Virginia*

5. 10:25 A Stratigraphic and Petrographic Study of the Acid Lava Flow in the basal Unicoi from Rockfish Gap to Swift Run Gap.  
R. G. Roane and W. C. Sherwood; *University of Virginia*
6. 10:40 A Petrographic Analysis of the Mosheim Formation at Strasburg, Virginia.  
W. C. Sherwood; *Virginia Council of Highway Investigation and Research*
7. 10:55 Pre-Middle Ordovician Channels in the Knox near Meadowview, Virginia.  
L. P. Harris; *Virginia Polytechnic Institute*
8. 11:10 Mineral Occurrences and Associations in the Albemarle Crushed Stone Quarry (Catoctin Formation) near Shadwell, Virginia.  
W. F. Giannini and W. K. Rector, Jr.; *University of Virginia*
9. 11:25 Remarks on a Carbonate-Derived Gossan near Stony Point, Virginia.  
J. F. Tazelaar; *University of Virginia*
10. 11:40 Mineral Transformations in Sediments of the Rappahannock Estuary, Virginia.  
B. W. Nelson; *Virginia Polytechnic Institute*
- 12:00 Recess
11. 2:00 Program of the Division of Mineral Resources.  
J. L. Calver; *Division of Mineral Resources*
12. 2:10 Some Worthies in Geology.  
J. K. Roberts; *University of Virginia*
13. 2:30 Symposium on Silica.  
Introduction. R. V. Dietrich; *Virginia Polytechnic Institute*
14. 2:40 The Use of Silica Sand for Providing Skid Resistance to Highway Surfaces.  
J. L. Eades; *Virginia Council of Highway Investigation and Research*
15. 3:00 Implications of Smoky Phantoms in Rock Crystal Quartz near Craigsville, Virginia.  
Whitman Cross, II and R. K. Peare; *University of Virginia*
16. 3:20 Conjugate Quartz Veins in the Lynchburg Gneiss near Fancy

Gap, Carroll County, Virginia.

B. H. Richard; *Virginia Polytechnic Institute*

17. 3:40 Cementation of Quartzose Sandstones of Virginia.  
W. D. Lowry; *Virginia Polytechnic Institute*
18. 4:00 Chert 'Pebbles' in a Basal Unicoi Conglomerate.  
R. V. Dietrich; *Virginia Polytechnic Institute*
- 4:20 Business Meeting

## Section of Medical Science

FRIDAY, MAY 9, — 10:00 A.M. — CAVALIER ROOM

Cornelia Hoch-Ligeti, *Chairman*

Robert H. Brownson, *Secretary*

W. Parker Anslow, Jr., *Section Editor*

1. 10:00 A Method for the Standardized Production of Irreversible Shock Following Hemorrhagic Hypotension in the Cat.  
Eugene D. Brand; *University of Virginia*
2. 10:15 A Relationship between Molecular Structure and Stimulation of Muscle Metabolism.  
D. R. H. Gourley; *University of Virginia School of Medicine*
3. 10:30 The Growth of Thyroidectomized Rats given 3,3',5-triiodothyronine.  
C. L. Gemmill; *University of Virginia School of Medicine*
4. 10:45 Studies on the Effects of Scurvy and Inanition on the Male Reproductive Tract.  
L. F. Cavazos; *Medical College of Virginia*
5. 11:00 Some Effects of X-irradiation on the Guinea Pig Brain with Reference to the Age Factor.  
R. H. Brownson; *Medical College of Virginia*
6. 11:15 Motion Pictures of Changes in Cells Induced by X-Ray Treatments of Tadpoles and Tetrahymenae.  
Carl C. Spiedel; *University of Virginia School of Medicine*
- 11:30 Business meeting.
7. 1:30 Tissue Cultures from Human Adult Bronchial Epithelium.  
Cornelia Hoch-Ligeti, *University of Virginia School of Medicine*

8. 1:45 Effects of Amphenone Administration on the Adrenal Response of Rats to Alcohol Intoxication.  
J. C. Forbes and G. M. Duncan; *Medical College of Virginia*
9. 2:00 A "New" Agglutinin against Stored Erythrocytes.  
Cecil Hougie; *University of Virginia School of Medicine*
10. 2:15 Effect of Temperature on Secretory Activity and Oxygen Consumption of Isolated Frog Skin.  
Ernst G. Huf and Norma S. Doss; *Medical College of Virginia*
11. 2:30 A Cell for Osmosis and Diffusion Studies of Isolated Secretory Membranes.  
Addison D. Campbell, Thomas E. Gilmer and Ernst G. Huf; *University of Richmond, Experiment Incorporated, and Medical College of Virginia*
12. 2:45 An Apparatus for the Study of Isolated Secretory Membranes of Automatically Controlled Membrane Potentials.  
Thomas E. Gilmer, Addison D. Campbell and Ernst G. Huf; *Experiment Incorporated, University of Richmond, and Medical College of Virginia*
13. 3:00 Metabolic Studies on Isolated Epithelium of Frog Skin.  
Leif Skjellvåle, Kathryn Nieder and Ernst G. Huf; *Medical College of Virginia*
14. 3:15 Ion Activities with Presence of Kidney Bries.  
Sidney Solomon; *Medical College of Virginia*

## Section of Psychology

Noble R. McEwen, *Chairman*

William E. Harris, *Executive Committeeman*

Penelope Lewis, *Secretary-Treasurer*

John K. Bare, *Section Editor*

FRIDAY, MAY 9 — 10:15 A.M. — POCAHONTAS ROOM

1. 10:15 Analysis of Variables Affecting Tracking Performance.  
Harold S. Schaus, Jr.; *University of Virginia*
2. 10:30 A Follow-up Study of School Related Referrals.  
Roberta Kiefer Simmons; *Norfolk Mental Hygiene Center*

3. 10:45 Variations of Whole-Part Methods of Learning and Experimenters.  
F. J. McGuigan; *Hollins College*
4. 11:00 Panel Discussion: The Improvement of the Teaching of Psychology.  
Moderator: Frank W. Finger; *University of Virginia*
5. 1:30 Cutaneous Electrical Delta I.  
Glenn R. Hawkes; *University of Virginia*
6. 1:45 Cutaneous Frequency Discrimination.  
Genevieve D. Goff; *University of Virginia*
7. 2:00 The Selection of Scientific Talent.  
Antonia B. Morgan; *Aptitudes Associates, Inc.*
8. 2:15 Stimulation of Discomfort and Relief in Written Documents.  
Dell Lebo and William Applegate; *Richmond Professional Institute.*
9. 2:30 The Control of Olfactory Stimuli.  
William R. Goff; *University of Virginia*
10. 2:45 Intermission
11. 3:00 Symposium: Achievement Imagery as Measured by the Iowa Picture Interpretation Test. *Chairman: Robert A. Johnson; Chairman: Robert A. Johnson; University of Richmond*  
A Further Investigation of the Effects of Achievement Imagery and Instructions on Maze Learning Performance.  
Ann Hunter; *University of Richmond*  
A Psycholinguistic Analysis of Speech Behavior in Groups Differing in Achievement Imagery.  
Rudolph F. Wagner; *Richmond Public Schools*; and John E. Williams; *University of Richmond*  
Achievement Imagery and A. C. E. Scores as Predictors of Grades in General Psychology.  
John E. Williams; *University of Richmond*  
Moderator: Stanley B. Williams; *College of William and Mary*
12. 4:15 Business Meeting: Virginia Psychological Association.  
William J. Morgan; *President*  
Gilbert J. Rich; *Vice-President*  
Cora Lynn Goldsborough; *Secretary*  
Jacob Silverberg; *Treasurer*

13. 6:00 Virginia Psychological Association Dinner at Toby's Lodge.  
*Address:* Current Legislature Problems for Psychologists.  
*Speaker:* Thomas W. Magoon; *University of Maryland*  
Dr. Magoon is President-elect of the Maryland Psychological Association and Co-chairman of the Legislative Committee of the Conference of State Psychological Associations.  
Transportation to Toby's Lodge will be provided. Members of the Section of Psychology are cordially invited to attend the dinner.

## SATURDAY, MAY 10 — 9:15 A.M.

14. 9:15 Pupillary Dilation to Spectral Stimuli.  
Robert H. Gibson; *University of Virginia*
15. 9:30 The Influence of Water Deprivation and Saline Injection Upon Thirst Behavior.  
James F. Campbell, Jr.; *University of Virginia*
16. 9:45 The Parental-Pathogens Test.  
Harold E. Paine; *Memorial Guidance Clinic*
17. 10:00 A Question: Who Should be the Patient?  
A. W. Jeffreys, Jr.; *Western State Hospital*
18. 10:25 Intermission
19. 10:35 A Repetition of the Miller Experiment on Acquired Fear.  
Raymond Kirby; *College of William and Mary*
20. 10:45 An Investigation of Taste Variables.  
John B. Feallock; *University of Virginia*
21. 11:00 Deprivation and the Day-night Cycle as Determiners of Food Intake.  
George Cicala; *College of William and Mary*
21. 11:15 Business Meeting: Section of Psychology.  
Noble R. McEwen, *Chairman*

## Section of Science Teachers

Vera B. Remsburg, *Chairman*

Mae Jennings, *Chairman-elect*

A. B. Niemeyer, Jr., *Secretary*

Caroline Gambrill, *Section Editor*

THURSDAY, MAY 8, 1:00 P.M. — PINE ROOM

1. 1:00 Present Status of Secondary Science in Virginia.  
Mr. Franklin D. Kizer — *Assistant Supervisor of Secondary Education*
2. 1:30 An Experiment in Science Education.  
Mary E. Kapp; *Richmond Professional Institute*
3. 2:00 Symposium on Quantitative Measurements in the Teaching of Science at All Levels.  
*Moderator:* James W. Cole, Jr.; *Director Academic Year Institute.* Members of the staffs of various science departments and participating teachers from the national Science Foundation Academic Year Institute of the University of Virginia will outline briefly some of the problems and present demonstrations of basic measurements in the fields of biology, chemistry, earth sciences and physics. Discussions of the topics will be from the viewpoint of classroom teachers.
4. 1:00 Teaching Materials. Booth 7.  
*Demonstrator:* A. B. Niemeyer

## Section of Statistics

N. L. Enrick, *Chairman*

J. W. Griswold, *Vice-Chairman*

R. A. Bradley, *Secretary*

C. Y. Kramer, *Section Editor*

FRIDAY, MAY 9 — 9:00 A.M. — WRITING ROOM

1. 9:00 Introductory Remarks by the Chairman.

2. 9:05 Combined Inter-and Intra-Block Analysis for Factorials in Incomplete Block Designs.  
R. E. Walpole; *Roanoke College*
3. 9:30 The Use of Response Surface Analysis on Biological Material.  
D. C. Hurst; *Virginia Polytechnic Institute*
4. 9:55 Triangle, Duo-Trio, and Difference from Control Tests in Taste Testing.  
R. A. Bradley; *Virginia Polytechnic Institute*
- 10:20 Intermission.

Session on Industrial Statistics

5. 10:30 Introduction to Statistical Sampling Inspection.  
G. F. White, Jr.; *Reynolds Metal Co.*
6. 10:55 Application of Variance-Length Curves in Product Quality Analysis.  
William D. Hicks; *Fieldcrest Mills, Leaksville, N. C.*
7. 11:20 Methodology for the Improvement and Analysis of Unsatisfactory Condition Data on a Complex Automatic Electro-Mechanical System.  
James R. Duffett; *Virginia Polytechnic Institute*
8. 2:00 Analysis and Reduction of Variations in the Processing Plant.  
N. L. Enrick; *Institute of Textile Technology*
9. 2:30 Application of Linear Programming to Dope Metering Pump Replacement.  
J. W. Cowdery; *Celanese Corporation of America*
10. 3:00 Business Meeting.
11. 3:30 Errors Associated with Process Adjustments.  
J. Edward Jackson; *Virginia Polytechnic Institute*, and R. A. Freund and W. G. Howe; *Eastman Kodak Co.*
12. 4:00 A Designed Experiment to Evaluate Seven Yarn Lubricants.  
H. M. Hill; *Tennessee Eastman Co.*

SATURDAY, MAY 10 — 9:00 A.M.

13. 9:00 Analysis of Variance of a Randomized Block Design with Missing Observations.  
W. A. Glenn and C. Y. Kramer; *Virginia Polytechnic Institute*
14. 9:25 Analysis of Variance of a Latin Square Design with Missing Observations.



Susan Glass; *Roanoke College* and C. Y. Kramer; *Virginia Polytechnic Institute*

15. 9:40 Significance Tests in Paired Comparisons.

T. H. Starks and H. A. David; *Virginia Polytechnic Institute*

10:05 Intermission.

16. 10:15 Generalized Distributions and the Problem of Confidence Statements in Multivariate Analysis.

Rolf Bargmann; *Virginia Polytechnic Institute*

17. 10:40 Some Probability Theory of Tests of Varied Components.

C. W. Clunies-Ross; *Virginia Polytechnic Institute*



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## NOTICE TO CONTRIBUTORS

Contributions to the Journal should be addressed to Robert T. Brumfield, Stevens Hall, Longwood College, Farmville, Virginia. If any preliminary notes have been published on the subject which is submitted to the editors, a statement to that effect must accompany the manuscript.

Manuscripts must be submitted in triplicate, typewritten in double spacing on standard 8½" x 11" paper, with at least a one inch margin on all sides. Manuscripts are limited to seven pages, with the proviso that if additional pages are desired, the author may obtain them at cost. The author may estimate the length of his paper by counting the total number of characters, including blank spaces, and dividing this by 3300. The result is the approximate number of printed pages in the Journal.

Division of the manuscripts into subheadings must follow a consistent plan, and be held to a minimum. It is desirable that a brief summary be included in all manuscripts.

Footnotes should be included in the body of the manuscript immediately following the reference, and set off by a dashed-line above and below the footnote content. Footnotes should be numbered consecutively from the beginning to the end of the manuscript.

Bibliographies (Literature Cited, References, etc.) should be arranged alphabetically according to author. Each reference should include the date, full title of the article, the name of the Journal, the volume, number (optional), pages, tables and figures (if any). For example: "Sniffen, Ernest W. 1940. Cobbles from the Pleistocene Terraces of the Lower York-James Peninsula Va. *Journ. Sci.*, 1 (8): 235-238. 1 fig., 1 tab. Reference to the bibliographic citations should not be made by numbers. Instead, using the above citations, where a reference is desired: either "Sniffen (1940)", (Sniffen, 1940: 186)", or "Sniffen (1940) states that . . ."

Explanation of figures, graphs, etc., should be typed on separate pages. All figures should be numbered consecutively beginning with the first text figure and continuing through the plates. If figures are to be inserted in the text this should be clearly indicated by writing "Figure —" at the appropriate place in the margin.

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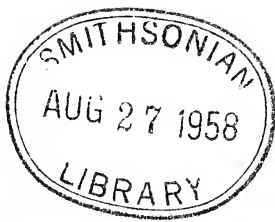
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Mailed August 5, 1958

# THE VIRGINIA JOURNAL OF SCIENCE

VOL. 9, NEW SERIES

JULY, 1958

No. 3

## The Comparison of the Sensitivities of Similar Experiments<sup>1</sup>

D. E. W. SCHUMANN<sup>2</sup> and R. A. BRADLEY

VIRGINIA AGRICULTURAL EXPERIMENT STATION

*of the*

VIRGINIA POLYTECHNIC INSTITUTE

*Blacksburg, Virginia*

### INTRODUCTION

In the subjective testing of foodstuffs no natural unit of measurement is available and it is common practice to use ranking methods or to construct a scoring scale on which the flavor and quality of food items are "measured" through the opinions of judges. The problem of comparing the sensitivities of such taste panel experiments that have been based on different scoring techniques or have been conducted by different judges is then raised.

Cochran (1943) discussed the problem of comparing different scales of measurement in a paper in which he confined his attention to the case in which all scales measure the same experiment. Assuming that analysis of variance techniques were applicable, he observed that a comparison of the sensitivities of two scales should depend both on the experimental errors associated with them and on the magnitudes of the treatment effects in the scales. Hence it was suggested that a comparison of scales should depend on a test of significance of the hypothesis that the parameters of two noncentral variance ratios were equal. Generalizing Cochran's concept of comparing scales of measurement, Schumann and Bradley (1957 a,b) have developed means of comparing the sensitivities of two identically designed independent experiments. In this paper we give the principal results obtained in the development of the theory and consider tests of significance with applications in various fields of research indicated.

1. A resume of original papers published in *Annals of Mathematical Statistics* 28(4), 1957 and *Biometrics* 13(4), 1957 but with a new example.

2. Now with the Department of Statistics, Stellenbosch University, Stellenbosch, South Africa.

Editor's Note: For this research, D. E. W. Schumann and R. A. Bradley were awarded the J. Shelton Horsley Award at the Thirty-fifth Annual Meeting of the Virginia Academy of Science. It is published here upon the request of the editors.

## FORMULATION OF THE PROBLEM

Let  $F'$  be a noncentral variance ratio with  $2a$  and  $2b$  degrees of freedom ( $a$  and  $b$  being integers or half-integers) and parameter of non-centrality  $\lambda$ . If

$$u' = \frac{2a F'}{2b}, \quad (1)$$

then  $u'$  has the density function

$$f(u'; a, b, \lambda) = \frac{u'^{a-1} e^{-\lambda}}{(1+u')^{a+b} B(a, b)} \cdot {}_1F_1(a+b, a; \frac{u' \lambda}{1+u'}) \quad (2)$$

for  $0 \leq u' < \infty$ , where  $B$  represents the beta function and

$${}_1F_1(a, b; x) = 1 + \frac{a}{b} \cdot \frac{x}{1!} + \frac{a(a+1)}{b(b+1)} \cdot \frac{x^2}{2!} + \dots$$

is the confluent hypergeometric function. In the usual additive analysis

of variance model with "fixed" parameters (Model I),  $\lambda = \frac{k}{2\sigma^2} \sum_{i=1}^t \tau_i^2$ , where

$k$  is the number of observations in each treatment mean,  $\tau_i$  is the effect of the  $i$ th of  $t$  treatments such that  $\sum_{i=1}^t \tau_i = 0$  and  $\sigma^2$  is the population error variance. It is obvious that the parameter  $\lambda$  is dependent on both the experimental errors and the magnitudes of the treatment effects. When  $\lambda = 0$ , (2) becomes the density of

$$u = \frac{2aF}{2b} \quad (3)$$

where  $F$  is the usual central  $F$ -statistic based on  $2a$  and  $2b$  degrees of freedom. Then

$$f(u; a, b, 0) = f(u, a, b) = \frac{u^{a-1}}{(1+u)^{a+b} B(a, b)} \quad (4)$$

for  $0 \leq u < \infty$ .

Now consider two *similar* experiments, that is, experiments with  $F$ -statistics (or  $F'$ -statistics) for treatment comparisons based on the same degrees of freedom, say  $2a$  and  $2b$ , and assume the experiments to be independent. The independent statistics  $u'_1$  and  $u'_2$ , as defined above, are then taken to be the appropriate statistics on which to base comparisons of the sensitivities of two scales or experimental techniques. We consider their ratio, say  $w' = u'_1 / u'_2$ . The null hypothesis of equal sensitivities



will then be equivalent to the hypothesis that  $\lambda_1 / k_1 = \lambda_2 / k_2$  where  $k_i$  ( $i = 1, 2$ ) is the number of observations in each treatment mean of experiment  $i$  and  $\lambda_i$  is the corresponding parameter of noncentrality. In this paper we will consider only the distribution of  $w'$  when  $u'_1$  and  $u'_2$  arise from two *identical* experiments i.e. experiments having  $k_1 = k_2$ . The hypothesis of equal sensitivities will then be that  $\lambda_1 = \lambda_2$ . While extensions to more general situations have been studied, further work has to be done to prove the accuracy and usefulness of some of the tests of hypotheses suggested for situations where the experiments are not identical or similar.

We shall also indicate how the method for the comparison of the sensitivities of experiments may be used to compare two population multiple correlation coefficients whose sampling distributions are based on regression models.

### DISTRIBUTION THEORY

Given similar experiments in which  $u'_1$  and  $u'_2$ , both with  $2a$  and  $2b$  degrees of freedom, are independent, the marginal distribution of  $w' = u'_1 / u'_2$  can be obtained from the joint distribution of  $u'_1$  and  $u'_2$ . The distribution of  $w'$  is<sup>3</sup>

$$g(w'; a, b, \lambda_1, \lambda_2) = e^{-\lambda_1 - \lambda_2} \sum_{r,s} \frac{\lambda_1^r \lambda_2^s}{r! s!} \frac{(w')^{a+r-1}}{B(a+r, b) B(a+s, b)} \\ \cdot H(w'; a, b, r, s), \quad 0 \leq w' < \infty,$$

where  $H(w'; a, b, r, s) = H(w') = (w'-1)^{-(2a+2b+r+s-1)}$

$$\cdot \int_1^{w'} \frac{(x-1)^{2a+r+s-1} (w'-x)^{2b-1}}{x^{a+b+r}} dx. \quad (5)$$

Now  $H(w')$  may be written in terms of hypergeometric functions:

3.  $r$  and  $s$  take all integral values  $0, 1, 2, \dots, \infty$  unless otherwise specified.

$$H(w') = B(2a+r+s, 2b) \cdot {}_2F_1(a+b+r, 2a+r+s, 2a+2b+r+s; 1-w') \\ \text{for } 0 \leq w' \leq 1,$$

$$= \frac{B(2a+r+s, 2b)}{(w')^{2a+r+s}} \cdot {}_2F_1(a+b+s, 2a+r+s, 2a+2b+r+s; \frac{w'-1}{w'}) \\ \text{for } 1 \leq w' < \infty,$$

where  ${}_2F_1$  is the hypergeometric function.

When  $\lambda_1 = \lambda_2 = \lambda$  we have  $g(w'; a, b, \lambda) = e^{-2\lambda} \sum_r \sum_s \frac{\lambda^{r+s}}{r! s!}$

$$\cdot \frac{(w')^{a+r-1}}{B(a+r, b) B(a+s, b)} \cdot H(w'; a, b, r, s) \quad (6)$$

The properties of  $g(w'; a, b, \lambda) = g(w')$  have been investigated. This is a density function with  $g(0) = 0$  and  $g(\infty) = 0$  for  $a, b > 1$ . In general  $g(w')$  is a unimodal distribution with mode between 0 and 1 and median at 1. Furthermore,  $g(w'; a, b, \lambda) = g(\frac{1}{w'}, a, b, \lambda)$ . The  $k$ th moment about zero is given by

$$\nu'_k = e^{-2\lambda} \cdot \frac{\Gamma(b+k) \Gamma(b-k)}{[\Gamma(b)]^2} \sum_r \sum_s \frac{\lambda^{r+s}}{r! s!} \frac{B(a+k+r, a-k+s)}{B(a+r, a+s)}$$

which is defined for  $a, b > k$  only.

On account of the complex nature of the density function of  $w'$ , a tabulation of the distribution is very nearly impossible with ordinary computing facilities. Even with  $\lambda_1 = \lambda_2$ , a three-parameter classification at each specified level of significance is required. An approximation to the density function was accordingly proposed based on the work of Patnaik (1949). Patnaik essentially approximated the distribution of  $F'$  with parameter  $\lambda$  and  $2a$  and  $2b$  degrees of freedom by a distribution of  $\frac{F}{c}$  with  $2a'$  and  $2b$  degrees of freedom, where  $c = \frac{a+\lambda}{a}$ ,  $a' = \frac{(a+\lambda)^2}{a+2\lambda}$  and  $F$  has the distribution of a central variance ratio. Following Patnaik's method, we approximate  $F'_i$  ( $i = 1, 2$ ) by  $\frac{F_i}{c_i}$  or  $u'_i$  by  $\frac{u_i}{c_i}$  where  $u'_i$  and  $u_i$  are defined in (1) and (3) respectively. When we have similar ex-

periments and  $\lambda_1 = \lambda_2 = \lambda$ , the ratio  $w' = u'_1 / u'_2$  is approximated by  $w = u_1 / u_2$  with  $2a' = \frac{2(a+\lambda)^2}{a+2\lambda}$  and  $2b$  degrees of freedom (the equivalent scale factors  $c$  cancel when the ratio is considered).

For the distribution of  $w$ , we have  $\lambda_1 = \lambda_2 = 0$  and the density function of  $w$  which approximates (6) can quite easily be obtained by setting  $\lambda = 0$  and writing  $a'$  for  $a$  in (6). This gives

$$g(w; a', b) = \frac{w^{a'-1} H(w; a', b)}{[B(a', b)]^2}, 0 \leq w < \infty, \quad (7)$$

where  $H(w; a', b) = H(w)$

$$= \int_0^\infty y^{2a'-1} [(1+wy)(1+y)]^{-(a'+b)} dy.$$

In general the lower moments of the density functions (6) and (7) tend to equality for large degrees of freedom, that is, large  $a'$  and  $b$ .

The distribution function of  $w'$ ,

$$G(w'_0; a, b, \lambda) = \int_0^{w_0} g(w'; a, b, \lambda) dw,$$

may be approximated by the distribution function

$$G(w_0; a', b) = \int_0^{w_0} g(w; a', b) dw = \frac{1}{[B(a', b)]^2} \int_0^\infty y^{a'-1} (1+y)^{-(a'+b)}$$

$$\frac{(w_0 y)^{a'}}{(1+w_0 y)^{a'}} \cdot \left[ \frac{1}{a'} - \frac{(b-1)w_0 y}{(a'+1)(1+w_0 y)} + \dots \right] dy$$

with  $a' = \frac{(a+\lambda)^2}{(a+2\lambda)}$  as above. The suitability of this approximation

was determined on the basis of comparing a limited number of values of  $G(w'_0; a, b, \lambda)$  and  $G(w'_0; a', b)$ .

Tables of values of  $w_0$  for which  $G(w_0; a, b) = 0.95$  were prepared and were published by Schumann and Bradley (1957a). Additional tables are in preparation. The tables are essentially triangular since it is known that  $G(w_0; a, b) = G(w_0; b, a)$ .

### TESTS OF HYPOTHESES ON SENSITIVITY

In the comparison of the sensitivities of identical experiments we shall be interested in a test of the null hypothesis  $H_0: \lambda_1 = \lambda_2 = \lambda$  against (i) a two-sided alternative  $H_a: \lambda_1 \neq \lambda_2$ , or (ii) a one-sided alternative  $H_a: \lambda_1 > \lambda_2$ . The test statistic is  $w' = u'_1 / u'_2 = F'_1 / F'_2$ ,  $F'_1$  and  $F'_2$  being independent noncentral variance ratios with parameters  $\lambda_1$  and  $\lambda_2$  respectively and both with  $2a$  and  $2b$  degrees of freedom. The test procedure is for (i) to reject  $H_0$  with significance level  $2\alpha$ , when  $w' > w'_0(\alpha)$  or  $\frac{1}{w'} > w'_0(\alpha)$  and for (ii) to reject  $H_0$  with significance level  $\alpha$  when  $w' > w'_0(\alpha)$ . The other one-sided alternative  $H_a: \lambda_1 < \lambda_2$  is included under (ii) by interchange of definitions of  $F'_1$  and  $F'_2$ . The cited table is used to obtain approximations of  $w'_0(\alpha)$  for  $\alpha = 0.05$ . We compute  $a'$  using  $a$  and an estimate of  $\lambda$  and interpolate (linearly) in the table to obtain the value of  $w_0$  that can be used as an approximation to  $w'_0(0.05)$ .

It is apparent that  $\lambda$  enters into the calculations as a nuisance parameter. Fortunately  $w'_0(\alpha)$  is not greatly affected by variations in  $\lambda$  and consequently it should have little effect in applications if we enter the tables using a value of  $\lambda$  somewhat different from its true (unknown) value. It is satisfactory to take  $\lambda$  as the average of  $\lambda_1$  and  $\lambda_2$ , which may be found through equating well known expectations of mean squares

to observed mean squares in the analysis of variance for the two identical experiments.

The basic steps in a test of hypothesis on sensitivity can be summarized as follows:-

1. Do analyses of variance for both experiments yielding  $F'$ -statistics valid for treatment comparisons, each with  $2a$  and  $2b$  degrees of freedom.

2. Estimate  $\lambda_1$  and  $\lambda_2$  pertaining to the two experiments and take  $\hat{\lambda} = \frac{1}{2}(\hat{\lambda}_1 + \hat{\lambda}_2)$  as an estimate of  $\lambda$ , where  $\hat{\lambda}_i$  ( $i = 1, 2$ ) is the estimate of  $\lambda_i$ . In Model I of the analysis of variance we take  $\overline{\hat{\lambda}_i} = a \begin{bmatrix} \frac{s_t^2}{s_e^2} & -1 \end{bmatrix}$

where  $s_t^2$  and  $s_e^2$  are respectively the mean squares for treatment and error of experiment  $i$ .

3. Formulate the null hypothesis  $H_0: \lambda_1 = \lambda_2 = \lambda$  and use  $\hat{\lambda}$  for the unspecified  $\lambda$  in subsequent calculations.

4. Decide on the significance level  $a$  to be used. (At present we are limited to  $a = 0.05$  since that table is the only one yet available to readers of this paper.)

5. Calculate  $w' = F'_1 / F'_2$  and  $a' = \frac{(a + \hat{\lambda})^2}{a + 2\hat{\lambda}}$  using  $\hat{\lambda}$  obtained in Step 2.

6. Enter the table with  $a'$  for  $a$  and with  $b$  and obtain  $w_0(0.05)$  by using linear interpolation. Compare  $w'$  with  $w_0(0.05)$  and accept or reject  $H_0$  in accordance with the procedure explained above with  $w_0(0.05)$  substituted for  $w'_0(0.05)$ .

### AN ILLUSTRATIVE EXAMPLE

As a numerical example, we consider data obtained by Kauman, Gottstein, and Lantican (1956) relating to an experiment in which subjective quality evaluations of twenty sheets of dried veneer were made

using two methods and three judges. Two schemes were used to evaluate quality of sheets of veneer and they were designated as *numerical* and *subjective* although both were considerably subjective. In the numerical scheme, various types of degrade were listed with numerical scores for the severity of the degrade and weights given for use in combining degrade scores to obtain a quality score. A quality score of fifty was very bad and the maximum attainable; a quality score of zero indicated a sheet free from degrade. In the subjective scheme, quality ratings were assigned on a 0 - 8 scale with 0, excellent and 8, very bad.

TABLE I

## ANALYSES OF VARIANCE FOR QUALITY RATINGS\*

Factor	Degrees of Freedom	Numerical Scheme		Subjective Scheme	
		Sum of Squares	Mean Square	Sum of Squares	Mean Square
Sheets (S)	19	12826.16	675.1	336.90	17.73
Observers (O)	2	170.72	85.36	3.70	1.852
Repetitions	3	168.13	56.04	0.61	0.2042
Interaction (SO)	38	823.61	21.67	30.12	0.7928
Error	57	595.37	10.45	22.13	0.3884

\* A reproduction of part of Table 6, Kauman, Gottstein, and Lantican (1956), page 148.

Twenty selected sheets of veneer were evaluated by three observers, twice with each scheme, and repeat observations were spaced by several days with the order of presentation of the sheets changed. Successive evaluations of the sheets by the observers will be taken to be independent. The more sensitive evaluation scheme will be defined to be the one exhibiting greater quality differences among the twenty sheets of veneer. Complete tables of scores are given in the reference; we repeat the analyses of variance in Table I.

The steps in the comparison of the sensitivities of Method 1 (the numerical scheme) and Method 2 (the subjective scheme) to differences in quality of the test sheets of veneer then give the following results:

1.  $F'_1 = 64.60$ ,  $F'_2 = 45.65$ ,  $a = 9.5$  and  $b = 28.5$
2.  $\lambda_1 = 9.5(64.60 - 1) = 604.2$ ,  $\hat{\lambda}_2 = 9.5(45.65 - 1) = 424.2$   
and we take  $\hat{\lambda} = \frac{1}{2}(604.2 + 424.2) = 514.2$ .
3.  $H_0: \lambda_1 = \lambda_2 = \lambda$  and  $H_a: \lambda_1 \neq \lambda_2$ .
4. Take the significance level as 0.10 i.e.  $\alpha = 0.05$ .
5.  $w' = \frac{64.60}{45.65} = 1.42$  and  $a' = \frac{(a+\lambda)^2}{a+2\lambda} = 264.2$ .
6. Enter the table in either cited references [Schumann and Bradley (1957 a,b)] with  $a = 264.2$  and  $b = 28.5$  or  $a = 28.5$  and  $b = 264.2$ . We find that  $w_0(0.05) \approx 1.85$ . Neither  $w'$  nor  $\frac{1}{w}$ , is significant in comparison with  $w_0(0.05)$ , the approximation of  $w'_0(0.05)$ , and we have no reason to reject  $H_0$ . It does not appear that the two methods of evaluating quality of veneer differ much in sensitivity to veneer-sheet differences. We are in accord with the authors (Kauman et al) who state: "The present experiment has shown that the subjective evaluation can yield results of an accuracy approaching that of the numerical scheme, although the accuracy of the latter was slightly superior".

#### TESTS OF HYPOTHESES ON MULTIPLE CORRELATION COEFFICIENTS

Consider the usual multiple regression equation with "fixed" or non-stochastic independent variables of the form

$$y = c_0 + c_1 x_1 + c_2 x_2 + \dots + c_p x_p.$$

If  $R$  is the multiple correlation coefficient based on  $N$  sets of observations

$(y_i, x_{1i}, \dots, x_{pi}), i = 1, \dots, N$ , it is well known that

$$u' = \frac{R^2}{1 - R^2} \quad \text{has the distribution } f(u'; a, b, \lambda) \text{ defined in (2)}$$

with  $a = p/2$ ,

$b = (N - p - 1)/2$ , and

$$\lambda = \frac{(a+b)\rho^2}{(1-\rho^2)} = \frac{(N-1)\rho^2}{2(1-\rho^2)}, \quad (8)$$

where  $\rho$  is the population multiple correlation coefficient estimated by  $R$ . Hence, if we have two independent corresponding multiple correlation coefficients  $R_1$  and  $R_2$  each based on  $p$  nonstochastic independent variables and  $N$  observation vectors, the distribution of

$$w' = R_1^2(1-R_2^2)/R_2^2(1-R_1^2) \quad \text{is given by (6) when } \rho_1 = \rho_2 = \rho,$$

with  $a$ ,  $b$ , and  $\lambda$  defined by (8). The theory and test procedures developed for a comparison of the sensitivities of identical experiments can therefore, be applied to compare multiple correlation coefficients. It must be observed that this does not apply to multiple correlation coefficients based on models in which it is assumed that the variables  $y, x_1, x_2, \dots, x_p$  follow a multivariate normal distribution.

To compare two multiple correlation coefficients in independent and identical experiments, we test the null hypothesis  $H_0: \rho_1^2 = \rho_2^2 = \rho^2$

against the alternative (i)  $H_a: \rho_1^2 \neq \rho_2^2$  or (ii)  $H_a: \rho_1^2 > \rho_2^2$ . The

test statistic is  $w' = R_1^2(1-R_2^2)/R_2^2(1-R_1^2)$  with both  $R_1$  and  $R_2$

based on  $p$  independent variables and  $N$  observation vectors. The test procedure is the same as for tests on the sensitivities of identical experiments given above.

The basic steps to be taken are:-

1. Obtain the multiple correlation coefficients,  $R_1$  and  $R_2$ , for the two experiments. Take  $a = p/2$  and  $b = (N - p - 1)/2$ .

2. Estimate  $\rho_i^2$  ( $i = 1, 2$ ) using  $\hat{\rho}_i^2 = 1 - \frac{(a+b)(1-R_i^2)}{b}$  as an



estimate of  $\rho_1^2$ , in the manner proposed by Snedecor (1950, p. 348).

Take  $\hat{\rho}^2$  to be the mean of  $\hat{\rho}_1^2$  and  $\hat{\rho}_2^2$ .

3. Formulate the null-hypothesis  $H_0: \rho_1^2 = \rho_2^2 = \rho^2$  using  $\hat{\rho}^2$  for  $\rho^2$ , and the suitable alternative.

4. Decide on the significance level to be used.

5. Calculate  $w' = R_1^2 (1 - R_2^2) / R_2^2 (1 - R_1^2)$  and

$$a' = \frac{(a + \hat{\lambda})^2}{a + 2\hat{\lambda}} = \frac{[p + (N - p - 1)\hat{\rho}^2]^2}{2(1 - \hat{\rho}^2)[p + (2N - p - 2)\hat{\rho}^2]}$$

6. Obtain  $w_0(a)$  as an approximation to  $w'_0(a)$  from the cited table with  $\alpha = 0.05$  by entering the table with  $a'$  for  $a$  and  $(N - p - 1)/2$  for  $b$ . Compare  $w'$  with  $w_0(a)$  and accept or reject  $H_0$ .

### CONCLUSION

In this paper we have indicated methods of comparing the sensitivities of experiments and multiple correlation coefficients. These methods are applicable in different fields of research. In taste testing experiments the procedures discussed here may be applied to compare the sensitivities of two scoring scales employed, two taste panels, two methods of preparation of test items or two environmental situations during testing, provided data are available from identically designed experiments in a form suitable for analysis of variance. In agronomy, especially in pasture experimentation where different (but comparable) methods of measuring the yields of forage mixtures are used, the sensitivities of the techniques relative to the differences between forage characteristics observed, may be compared. In electronics it may be possible to compare experiments based on accelerated life tests with experiments based on normal life tests, or to compare the sensitivities of alternative means of conducting accelerated life tests. In physics and chemistry two similar experiments might be conducted and their sensitivities compared to determine which method of experimentation is to be used in routine experiments.

The methods of comparing the sensitivities of experiments are applicable in the case of independent experiments with F ratios based on the same degrees of freedom and with the same number of repetitions in each treatment mean. There are some situations wherein the sen-

sitivities of experiments that do not meet the requirements of similarity should be compared. Some suggestions have been made for tests of hypotheses applicable in these cases but their appropriateness must still be investigated.

The extension of tables for the tests of significance outlined in this paper is being undertaken and tables of the upper 2.5%, 1% and 0.05% points of the distribution function  $G(w_0; a, b)$  are under construction.

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## Tetrahymena rostrata as a Facultative Parasite In the Grey Garden Slug

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Two species of holotrichous ciliates have been designated as facultative parasites in the grey garden slug, *Deroceras agreste* L. (*Deroceras reticulatum* Muller). Reynolds (1936) reported *Colpoda steini* from the respiratory chamber and liver tubules of slugs inhabiting the "grounds" of the University of Virginia. Warren (1932) described *Paraglaucoma limacis* from slugs in the vicinity of Pietermaritzburg, Natal. After studying a ciliate found in the grey garden slugs collected from Washington and Oregon, Kozloff (1946) concluded that this protozoon was identical with *Paraglaucoma limacis* of Warren and that both should be included in the genus *Tetrahymena* as *Tetrahymena limacis*. Borden (1948) reported both *Colpoda steini* and *T. limacis* from the slugs collected from the "grounds" of the University of Virginia.

*Tetrahymena rostrata* (Kahl, 1926) Corliss was described as a free living ciliate from European and American mosses. Its role as a facultative parasite was first reported in New Zealand (Stout, 1954) where it was found to infect enchytraeid worms. The second such case of parasitism was discovered by the present writer in *Deroceras reticulatum* collected from Culpeper, Virginia in 1955.

### MATERIALS AND METHODS

Silver impregnation (Corliss, 1953a) was employed to determine the important pellicular structures of *Tetrahymena rostrata*. Delafield's haematoxylin was used as a nuclear stain. Studies of the living ciliates were made with both phase and ordinary light microscopy. Bacteria-free clone cultures of the ciliate were established in medium consisting of two per cent proteose-peptone plus one-tenth per cent of liver fraction L.

### OBSERVATIONS AND RESULTS

While examining a grey garden slug for facultative parasites, large protozoan cysts were found in the fresh feces. These cysts were few in number but appeared repeatedly, even after weeks of feeding on washed lettuce. Excystment took place in tap water and the ciliates were cultured on bacterized meat culture. Subsequent morphological studies were made and the ciliate identified as *Tetrahymena rostrata*. In general, the

morphological features of the slug parasite agreed with earlier descriptions of *T. rostrata* but in addition a single caudal cilium was noted. This cilium appeared about twice the length of a regular body cilium and did not beat as the other cilia but often seemed to trail behind. It was not a "stiff-bristle" but was seen to bend in body movements.

A clone culture was established in axenic medium (Holz and Thompson, 1955). In experimental infections of various animals using axenic strains of the genus *Tetrahymena*, *T. rostrata* was able to infect Betsy beetles, wood feeding roaches, dragonfly nymphs, and tent caterpillars when injected into the body cavity.

When morphological studies were made on *T. rostrata* cultured in axenic medium, a variation in ciliary rows was noted. Meridional counts made from bacterized cultures ranged from 28 to 32 with a mode of 30. From axenic cultures the meridional counts ranged from 27 to 48 with a mode of 33. Many bizarre ciliates appeared here and the ciliary meridians were often not oriented in the usual manner but appeared somewhat as altitude contours of a mountain peak.

## DISCUSSION

Stout (1954) in his description of *T. rostrata* from enchytraeid worms gave the first good morphological description of the ciliate. But he failed to identify the single caudal cilium or the third buccal membranelle which were found in the slug parasite. These structures were later observed by the present writer in a culture of *T. rostrata* sent by Dr. Stout from the enchytraeid infections.

Borden (1948) was probably the first investigator to observe *T. rostrata* as a facultative parasite. In her study she reported *T. limacis* from 8 of the 117 slugs examined. She reported that ciliates in old cultures "in some cases acquired a cyst wall, and finally died. Division was observed in some of the cysts". Since *T. limacis* has never been known to produce cysts and since *T. rostrata* is the only species of the genus that forms both resting and reproductive cysts, it is very likely that this species was present in some of Borden's cultures.

Stout supported Corliss (1953b) in declaring *T. rostrata* an obligate histophage but since the ciliate has been established in both axenic and bacterized cultures this can no longer be supported. Also the present writer observed this ciliate to feed on algae.

Kozloff (1956) noted a variation in meridian counts of *T. limacis* grown in axenic medium from those found as facultative parasites in the slug. But here only a decrease in number was reported. Since this

phenomenon was also noted for *T. rostrata*, future protozoan descriptions should not base meridian counts solely from axenic cultures.

The ability of *T. rostrata* to establish experimental infections in the body fluids of various insects suggests that in nature insects may often serve as natural hosts for this ciliate.

### SUMMARY

Large protozoan cysts were found repeatedly in the feces of *Deroceras reticulatum* even after weeks of feeding on washed lettuce. Morphological studies were made and the ciliate identified as *Tetrahymena rostrata*, normally a free living protozoan.

Clone cultures were established in axenic medium. Later morphological studies of ciliates from axenic cultures revealed a variation in the number of meridians from ciliates cultured on bacterized medium.

*T. rostrata* was experimentally established as a parasite in the body fluids of certain insects.

### ACKNOWLEDGMENT

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# The Ovule and Embryo Sac of Galax Aphylla

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*Galax aphylla* L. is a monotypic herbaceous perennial of the family Diapensiaceae. According to Baldwin (1941), it occurs naturally from northern West Virginia and northwestern Maryland to central Georgia and central Alabama and from eastern Virginia to central Tennessee.

According to Gray (1873), Lindley established the order Diapensiaceae in 1836. A survey of the literature published since that time reveals no paper which describes ovule and embryo sac development in *Galax*.

## MATERIALS AND METHODS

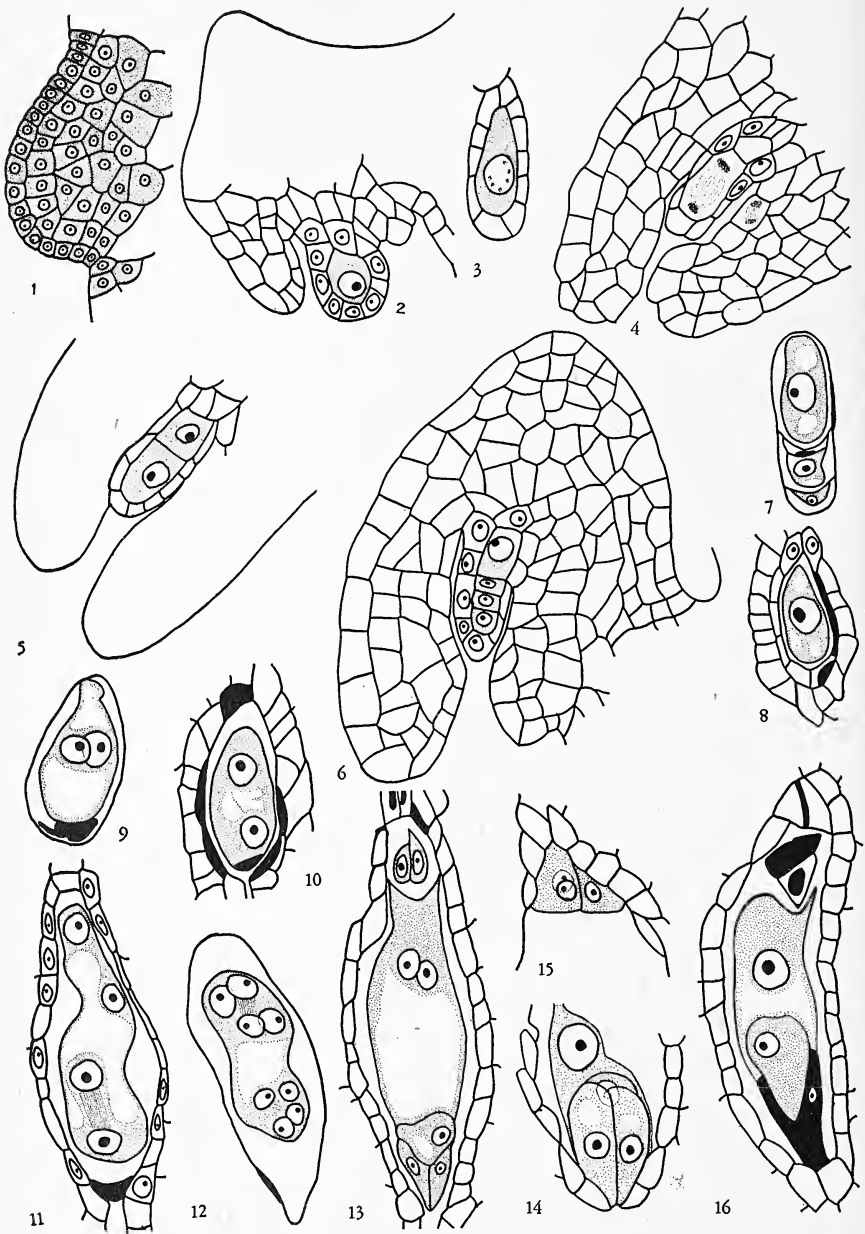
Buds and flowers were fixed in the field in a formalinaceto-alcohol solution. Sections were cut at 22-30  $\mu$  and stained in safranin and fast green. Drawings were made with the aid of a camera lucida, each from a single section.

## OBSERVATIONS

The pistil of *Galax aphylla* is three-carpellate. In each of the three locules, the placenta is axile in position, the ovules are few to numerous, and ovule arrangement on the placentae is somewhat varied, so that only a small number of sections are available for development study in longitudinal sections of the pistil.

The ovule arises as a protuberance of meristematic cells from an axile placenta of an immature flower (fig. 1.) As it becomes more prominent, the young ovule turns as a result of unequal growth. At this stage the single primordial integument of the ovule emerges (fig. 2). This single integument, which is from 4-6 cells in thickness, soon envelops the tip of the nucellus except for a small opening, the micropyle (fig. 4-6).

Just prior to or simultaneously with integument formation the single subepidermal archesporial cell becomes differentiated. The archesporial cell is larger than the surrounding nucellar cells and contains a large nucleus and nucleolus (fig. 2). As the archesporial cell, which is polygonal in shape and enlarges mostly by elongation parallel to the long axis of the ovule, becomes the megaspore mother cell, the ovule approaches the





anatropous condition (fig. 2-6). The first meiotic division of the megaspore mother cell forms two dyad cells (fig. 4-5). The megaspore mother cell upon completion of the second meiotic division forms four megaspores arranged linearly (fig. 6). The three micropylar megaspores disintegrate leaving the chalazal one as the functional megaspore. The disintegrated spores are characterized by a collapse of the cell walls, by a dissolution of the nuclei, and by a deep staining reaction of the remaining cytoplasm (fig. 7-8).

During enlargement and elongation of the functional megaspore, the three micropylar megaspores disintegrate and a vacuole appears at each end of the cell with the nucleus remaining in the center (fig. 7). Development into an embryo sac begins when this centrally located nucleus divides forming two daughter nuclei (fig. 9). The migration of the two small vacuoles and their fusion between the nuclei results in a two-nucleated embryo sac in which one nucleus is located at the micropylar end of the sac and the other at the chalazal end (fig. 10). As the embryo sac continues development, the nucellus disintegrates and disappears except for occasional disintegrated cells which can be seen due to their deep staining reaction (fig. 10). A division of the two nuclei occurs and a four-nucleated sac is formed (fig. 11). Each of the four nuclei then divides giving rise to an eight-nucleated sac (fig. 12). The eight nuclei are arranged in quartets, a micropylar one and a chalazal one. Shortly after development reaches the eight-nucleated stage, one nucleus from each quartet migrates toward the center of the sac. The formation of the mature embryo sac, which includes an egg and two synergid cells, the egg apparatus at the micropylar end, two centrally located polar nuclei, and three antipodal cells at the chalazal end, is now completed (fig. 13-15).

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Fig. 1-16. x 166.—Fig. 1. Ovule arises as a protuberance of meristematic cells. Fig. 2. Integument becomes differentiated; nucellus with archesporial cell. Fig. 3-5. First division of the megaspore mother cell showing formation of dyad cells. Fig. 6. Anatropous ovule; nucellus with four megaspore in linear arrangement. Fig. 7-8. One-nucleated embryo sacs; megaspore disintegration. Fig. 9-10. Two-nucleated embryo sacs. Fig. 11. Four-nucleated embryo sac. Fig. 12. Eight-nucleated embryo sac. Fig. 13. Seven-celled, eight-nucleated embryo sac showing the three cells of the egg apparatus, the two polar nuclei, and two of the three antipodal cells. Fig. 14. Portion of embryo sac showing egg apparatus and secondary polar nucleus. Fig. 15. Portion of embryo sac showing arrangement of the three antipodal cells. Fig. 16. Zygote and primary endosperm nucleus; note antipodal and synergid disintegration.

Shortly after the mature embryo sac is formed, the polar nuclei fuse to form a large secondary polar nucleus (fig. 14). After fertilization occurs, the three antipodal cells and the two synergid cells disintegrate (fig. 16).

Development, therefore, in *Galax aphylla* follows the *Polygonum*-type. A comparison between ovule and embryo sac formation in *Galax aphylla* and *Diapensia lapponica*, as described by Samuelsson (1913), reveals that they closely parallel one another.

### SUMMARY

The development of the anatropous ovule and the *Polygonum*-type embryo sac of *Galax aphylla* is described. A single subepidermal arche-sporial cell, surrounded by a single evanescent layer of nucellar cells, after lengthening parallel to the long axis of the ovule functions as the megaspore mother cell. The four megaspores formed from the megaspore mother cell are arranged linearly. As the chalazal megaspore develops into a seven-celled, eight-nucleated embryo sac, the three micropylar megaspores disintegrate.

### ACKNOWLEDGMENTS

The author is indebted to Dr. E. M. Betts of the Miller Biological Laboratories, University of Virginia for suggesting the problem and to the National Science Foundation for financing the work.

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## Some Curious Analogies in Explorers' Preconceptions of Virginia

GARY S. DUNBAR

*Department of Geography*

*University of Virginia*

Early observers made ample errors in interpreting Virginia's natural landscapes after they had viewed them, but even more curious were the views they held concerning this land before they arrived. The English, who had learned precious little about the New World after almost a century of Spanish voyaging, had to rely upon rumors, fanciful *mappaemundi*, and analogies from known lands for their information about temperate America. Lacking real knowledge, the English confidently presumed that the climate, topography, and mineral resources of North America would be the same as those of the same latitudes in Eurasia and in Spanish South America.

Still untested by adequate observation, the classical notion of rigid latitudinal zonation of climates was regarded as immutable by Europeans. Even before Raleigh's first expedition to Roanoke Island returned to England, Richard Hakluyt, the famous English arm-chair "geographer" (really just a compiler of travel narratives), prepared his "Discourse of western planting" which stated that Mediterranean crop plants could easily grow in the same latitudes in North America (Taylor, 1935). Thomas Hariot, the accurate scientific observer, spent the winter of 1585-1586 in what is now northeastern North Carolina and southeastern Virginia, but he reported only that the climate was "answerable to . . . the South part of Greece, Italy, and Spaine." (Quinn, 1955). Thus the original belief that Virginia's climate should be the same as that of the Mediterranean lands because of the sameness of latitude was reinforced by a veracious traveler who had wintered there. John Smith was among the first to modify the view that lands in the same latitude necessarily have the same climate when he said concerning Virginia: "The sommer is hot as in *Spaine*; the winter colde as in *Fraunce* or *England*" (Smith, 1910). However, Virginia has humid, not dry Mediterranean, summers, and even though the average January (coldest month) temperatures at Jamestown and London are about the same, nevertheless the former has a greater range and experiences more frequent change. When the more northerly colonies of New England and the Middle Atlantic region were settled, their cold winters could not be compared at all with England's,

and yet the homeland lay in higher latitudes than all the American colonies. The colonists could simply not understand the climatic differences between east coast and west coast locations.

The Jamestown explorers set out with some odd notions about the size and shape of the North American continent. Hope apparently still persisted in finding the "Sea of Verrazano" not far from the Atlantic seaboard (Cumming, 1938). The 1607 colony was instructed by the London Company to commence exploration immediately to reach this sea not far to the westward. The explicit instructions read as follows:

You shall do your best endeavour to find out a safe port in the entrance of some navigable river . . .

You must observe if you can, whether the river on which you plant doth spring out of mountains or out of lakes. If it be out of any lake, the passage to the other sea will be more easy, and (it) is like[ly] enough, that out of the same lake you shall find some spring which run (s) the contrary way towards the East India Sea; for the great famous rivers of *Volga*, *Tan (a) is* [Don], and *Dwina* have three heads near joyn (e) d; and yet the one falleth into the *Caspian* Sea, the other into the *Euxine* [Black] Sea, and the third into the *Paelonian* [White] Sea (Smith, 1910).

These instructions show that the English believed in the close proximity of the "East India Sea" to the Atlantic in the latitude of Chesapeake Bay and that they further hoped that the river systems of North America were similar to those of Russia where rivers whose sources are close together flow in different directions and provide easy transport from sea to sea. They apparently believed that the continents were so much alike in their natural features that such a prediction about North America was justified. The men of the 17th century were naturally unaware that the Russian situation was largely the result of heavy continental glaciation, a configuration without parallels in Virginia (Taylor, 1934).

William Berkeley, governor of Virginia from 1642 to 1652 and from 1660 to 1677, was from the beginning of his term interested in the fur trade and also in the possibility of finding a water route to Asia. In 1669 he wrote the following to Lord Arlington:

I did this last spring resolve to make an Essay to doe his Majestie a memorable service which was in the Company of Two hundred Gent who had engaged to goe along with me to find out the East India sea, and we had hopes that in our Journy we should have found some Mines of silver; for certaine it is that the spaniard in

the same degrees of latitude has found many. But my Lord unusual and continued Raynes hindred my intentions (Alvord and Bidgood, 1912).

Here Berkeley is not only stating his belief in the nearness of the East India Sea but also shows that he subscribed to the time-honored notion that lands in the same latitudes possessed identical mineral resources. Earlier, in 1616, John Smith had also voiced this view when he said, concerning New England: "Southward, in the same height [latitude], is the richest of gold Mynes, *Chily* and *Baldiua*, and the mouth of the great Riuer of *Plate*, &c." (Smith, 1910).

Another analogy with South America was drawn by John Lederer, the mysterious German physician whom Berkeley allowed to make three trips westward from the Virginia settlements in 1669 and 1670 with the intention of finding the East India Sea but who never went beyond the Blue Ridge. Lederer embellished his account with tales of pearls and peacocks, and, although he never even penetrated the Great Valley, concluded that the "Indian ocean" was to be found just on the other side of the Appalachians. He stated:

I am brought over to their opinion who think that the Indian ocean does stretch an arm or bay from California into the continent as far as the Apalataean mountains, answerable to the Gulfs of Florida and Mexico on this side. Yet I am from believing with some, that such great and navigable rivers are to be found on the other side the Apalataeans falling into the Indian ocean, as those which run from them to the eastward. My first reason is derived from the knowledge and experience we already have of South-America, whose Andes send the greatest rivers in the world (as the Amazonas and Rio de la Plata, etc.) into the Atlantick, but none at all into the Pacifique sea. (Alvord and Bidgood, 1912).

Lederer did not realize that the Andes, even though they lie close to the sea, do "send" some rivers down to the Pacific and also that the Appalachians are in no way comparable to the great western cordillera of South America.

These examples demonstrate the inherent pitfalls in the early explorers' attempts to predict what the natural landscapes of unknown lands would be like by analogy with known lands of the same latitude. As the colonists gained in experience they realized that latitude alone is not an indicator of climate—and certainly not of shapes of continents, the nature of river systems, and of the location of mineral bodies.

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## News And Notes

(*Editor's Note: News contributions should be sent to the person whose name appears at the end of the appropriate sections.*)

### MINUTES OF COUNCIL MEETING

Virginia Academy of Science, Richmond, Va., March 8, 1958

The meeting was held at the Rotunda Club in the Hotel Jefferson; it was called to order at 10:40 a.m. by the president.

The following council members were present: William G. Guy; John C. Forbes; Horton H. Hobbs, Jr.; Edward S. Harlow; Charles F. Lane; Lynn D. Abbott; Walter S. Flory, Jr.; Mrs. B. G. Heatwole; Thomas E. Gilmer; Foley F. Smith; William M. Hinton; William B. Wartman, Jr., and Irving G. Foster. Boyd S. Harshbarger and Sidney Negus also attended at the request of President Guy.

The assistant secretary-treasurer read the minutes of the last meeting. After one minor change, they were approved.

The president reported that he had requested Dr. Cooper of Virginia Polytechnic Institute to write a tribute to the late Marcellus Stow, which would be published in the January issue of the Journal. Council endorsed this action taken by the president. *The Seashore Science Center Proposal*: The president reported that no further action had been taken on this proposal.

*Report of the Committee to Survey the Need for Research Funds by Faculty Members of Academic Institutions in Virginia, principally those in Smaller Institutions for Research Projects During the Summer Months*: Dr. Forbes reported that a survey of eleven institutions showed that such a need did exist, with seventy-five persons from ten institutions expressing an interest in securing such funds. He suggested that an initial sum of \$25,000 would be needed and that a grant of about \$1,000 would enable a faculty member to devote the summer months to a research project. There was considerable discussion as to possible sources of such funds, the procedure to follow in securing these funds and the role the Academy should play in this project. A motion was passed that the president appoint a committee to further pursue this project, especially as to ways and means of securing the necessary funds and the role the Academy should play in the project, this committee to submit a report to the Council.

*Report of the Treasurer and the 1958 Budget*: In his report the

treasurer stated that the auditor had not completed the tax report and therefore had not submitted a statement for the audit of the treasurer's records for the two-year period ending December 31, 1957. As a consequence, Council delayed action on the question of an annual or a biannual audit of the treasurer's records. Walter Flory suggested that a monetary savings could be effected by an annual review of the treasurer's records by all Academy committees as was done for the year 1956. In view of the anticipated increase in postage rates, the treasurer requested that the budget item "postage, addressograph service and section expense" be increased from \$250 to \$300.

Charles F. Lane, Managing Editor of the Journal, reported on the financial status of the Journal. Again, he reported that the increasing costs of publication of the Journal without increased revenue was rapidly exhausting the reserve funds. He stressed the necessity of either curtailing the material published in the Journal, thereby reducing publication costs, or an increase in Journal funds. Among the suggestions proposed for alleviating this condition were: (1.) Discontinue publishing the General Program of the Annual Meeting in the Proceedings, since this is published in the annual April issue. (2.) Reduce the "News and Notes" copy. (3.) Increase the advertising revenue.

The estimated income of the Academy for 1958 would not permit raising the funds allocated to the Journal in the 1958 budget without the possibility of deficit financing. A motion was passed that the 1958 budget be approved as presented by the Finance and Endowment Committee with the provision that should additional funds become available, the budget would be revised accordingly.

A motion was passed that the chairman of the Finance and Endowment Committee be requested to appoint a member of his committee as chairman of the Subcommittee on Business Memberships.

As requested in the minutes of the Finance Committee Meeting on February 20, 1958, a motion was passed approving the appointment of a subcommittee by the chairman of the Finance and Endowment Committee to raise fifteen hundred dollars during the calendar year.

A motion was passed that the president request the Editor of the Journal to present at the next Council meeting suggested ways and means of effecting savings in the printing costs of the Journal.

*Proposal that the Virginia Academy of Science Participate in the Joint Coordinating Committee of Engineering Societies:* The report of Henry Leidheiser and Bernard Niemeier, submitted in writing, recommended "that the V.A.S. not become a charter member of the Joint Co-



ordinating Committee of Engineering Societies but follow its activities closely and join in the group later if the nature of its activities justifies such action." A motion was passed that Council accept the report and its recommendation.

*Report of the Local Arrangements Committee:* Boyd Harshbarger, chairman of the committee, suggested that information on housing accommodations and a brief program of activities, including section meetings, be mailed to the membership as soon as possible.

A motion was passed that the chairman of the Local Arrangements Committee assemble this information and transmit it to the secretary for mailing to the membership.

*Future of the James River Project and Jamestown Festival Project:* The president appointed Foley Smith temporary chairman of the James River Project Committee.

A motion was passed that the Jamestown Festival Committee be abolished and that the activities of this committee be assumed by the Long-Range Planning Committee.

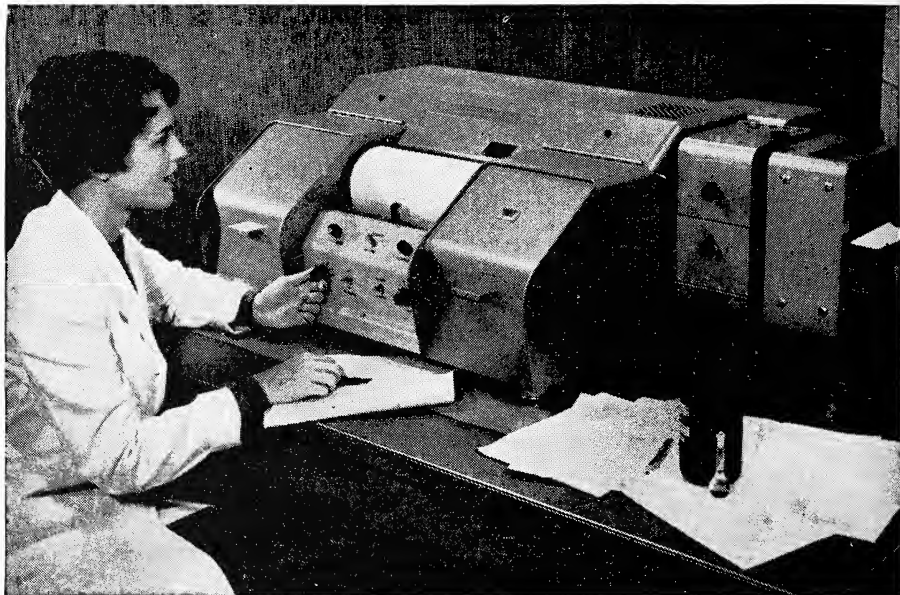
A possible project in science education to be submitted to the Academy Conference for financial support from A.A.A.S. was discussed but the matter was left 'open' pending the submission of any acceptable proposal. The president reported that the secretary had submitted the nomination of the following persons as possible representatives of the Academy at the A.A.A.S. meeting of American scientists to be held at Washington, D. C., on March 15-17: James W. Cole, Jr., Arthur Bevan, and Jesse W. Beams.

The Council members were guests at luncheon of president-elect Forbes and after going on record in expressing their deep appreciation of his generous hospitality, the meeting was adjourned at 2:30 p.m.

—W. B. Wartman, Jr., *Assistant Secretary-Treasurer*

#### AGRICULTURAL SCIENCE

C. J. Ackerman, Associate Professor in the Department of Biochemistry and Nutrition, Virginia Polytechnic Institute, participated in the 10th Annual Research Conference sponsored by the Research Advisory Council of the American Meat Institute Foundation and presented a paper on the subject, "Growth Promoting Properties of Meat Meal." Ackerman was one of approximately 15 noted scientists who gave papers at this meeting. Four hundred individuals representing the meat packing industry



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and university and government agencies attended this recent meeting held at the University of Chicago. Ackerman has studied the alleviation of the rat growth depressing effect of the sulfa drugs by meat meal.

John P. Garber, a junior in the Department of Dairy Science, Virginia Polytechnic Institute, received the 1958 Ralston Purina undergraduate award of \$500. The award is based on academic proficiency, need, and extra-curricula activities.

M. F. Ellmore of the Department of Dairy Science, Virginia Polytechnic Institute was elected to the Graduate Studies and Degrees committee of the Agricultural Faculty at its May meeting. G. C. Graf, Head of the Department of Dairy Science, was elected as the Agricultural Faculty representative on the Virginia Polytechnic Institute Advisory Committee on Academic Freedom and Tenure at the same meeting.

George G. Green, with his graduate work at Texas Agricultural and Mechanical College, was appointed Associate Professor of Animal Husbandry, Virginia Polytechnic Institute, to replace Owen Thomas, III, who resigned to be Secretary of the Virginia Hereford Association.

Charles R. Cooper, Assistant County Agent, Franklin, Virginia, was appointed Assistant Professor of Animal Husbandry to do 4-H Extension project work. He replaces A. N. Huff, who is in the Armed Forces.

E. C. Turner, Jr. and E. M. Raffensperger, Biology Department, Virginia Polytechnic Institute, attended a workshop on the use of systemic insecticides in control of livestock insects at Kansas State College in May. The workshop was sponsored jointly by the United States Department of Agriculture and the Entomological Society of America.

The Virginia Crop Reporting Service participated in a research project sponsored by the U. S. Crop Reporting Board designed to forecast the yield of corn by making objective measurements in sample field plots. Fifty sample corn fields were selected at random with two sample plots likewise selected in each field. Counts and measurements were made monthly beginning in late July. Corn in the sample plots was harvested and weighed when mature and sample ears taken for moisture content and shell-out percentage. A post-harvest check was made to determine harvesting loss. Results indicate that an accurate forecast of yield per acre can be made as early as September 1 with a small sample.

Recent additions to the staff of the Division of Chemistry and Foods, Virginia Department of Agriculture, are: Raymond B. Ashworth (University of Georgia), Jesse E. Swann, Thomas E. Marek and Charles E. O'Rear (Virginia Polytechnic Institute), A. Gregory Howe (University

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of North Carolina) and Meade F. Kientz (Madison College).

K. W. King of the Department of Biochemistry and Nutrition and the Department of Biology joined a nutritional survey team in Haiti late in May to assess the nutritional and health status of rural people in Haiti. Nutritional surveys have been made in Korea, the Phillipines, Iran, Pakistan, Turkey, Libya, and Guatemala. Last summer, C. J. Ackerman, also of the Department of Biochemistry and Nutrition, served with the team in Libya. The Virginia Academy of Sciences has provided Dr. King with additional funds for sending samples of Haitian soils, insects, and plants to several researchers at Virginia Polytechnic Institute. These samples will be used in the research programs of R. W. Engel and N. O. Price of Biochemistry and Nutrition, C. I. Rich in Agronomy, E. C. Turner and W. G. Evans in Entomology, and P. C. Holt, W. E. Moore, and W. W. Scott in Biology.

Russell F. Miller of the Department of Biochemistry and Nutrition has been elected to membership in the American Institute of Nutrition. He is the second faculty member in the history of Virginia Polytechnic Institute to be honored. Election to the society was in recognition to his basic researches of the mineral nutrition of laboratory and farm animals which clarified the nutritional interactions of molybdenum, copper, and sulfur in the diet and the fate of dietary fluorine.

—Carl Allen, *Virginia Polytechnic Institute*

#### ASTRONOMY, MATHEMATICS, PHYSICS

Stephen Berko of the Physics Dept. of the University of Virginia has been awarded a Sloane Foundation Fellowship for the coming academic year. He will be at the Niels Bohr Institute in Copenhagen.

James Hollinger and A. J. Zuchelli, presently graduate students at University of Virginia will study in England next year. Dr. Zuchelli will be at the University of Birmingham as a National Science Foundation Post-Doctoral Fellow, and Mr. Hollinger will attend Cambridge University on a Fulbright Fellowship.

Miss Isabel Boggs will retire this June after thirty-eight years of service in the Physics Dept. of Randolph-Macon Woman's College. Her new address is 14 Parkmont Apts., Lynchburg.

Gordon Stipe is leaving the state to accept a position as Associate Professor of Physics at Boston University. He has been at Randolph-Macon for several years.

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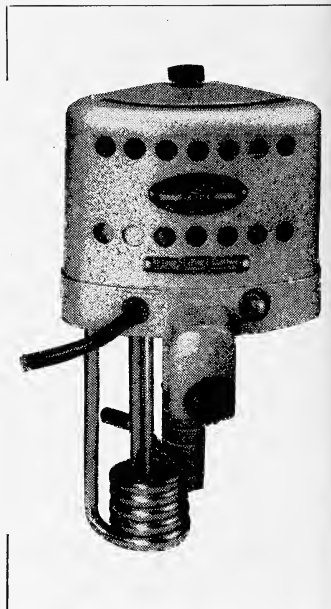
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The new Physical Science Building at Lynchburg College will be ready for occupancy this fall. It will house the departments of Mathematics, Physics, Chemistry, and Biology.

Randolph Early will join the Physics Department of Lynchburg College in September, as an instructor.

Billy Sloope of the Physics Dept., University of Richmond has been promoted to Associate Professor.

T. E. Gilmer of Hampden-Sydney College will be associate director of the NSF Summer Institute for high school teachers at Converse College.

W. T. Joyner, has joined the staff of Hampden-Sydney College as Assistant Professor of Physics. He is a graduate of Hampden-Sydney and received his graduate training at Duke University.

J. W. Sherman, III, will join the Hampden-Sydney faculty in the fall as Instructor in Mathematics and Physics.

Dorothy Montgomery will be on sabbatical leave from Hollins College during the coming year. She will be at Massachusetts Institute of Technology to work with Dr. Facharias and the committee on secondary school teaching of physics supported by the NSF. Her particular interest is in the preparation of film strip material.

I G. Foster, *Dept. of Physics, Virginia Military Institute*

#### BACTERIOLOGY SECTION

The Virginia Branch of the Society of American Bacteriologist will assist students and science teachers in planning projects and giving guidance in the area of microbiology for participants in the exhibits of the Junior Academy. In order to emphasize its interest, the Section has established an award of \$25.00 and a certificate for the outstanding exhibit or scientific paper on microbiology presented at the annual meeting of the Junior Academy of Science. This year two awards were given: First Prize, Billy Ridenour (sponsored by Mrs. R. B. Painter) of the William Fleming High School in Roanoke for "Induced mutations of *E. coli* by metabolic substitution"; Second Prize, Betsy Gilfoyle (sponsored by Mrs. Elizabeth Charlton) of the York High School in Yorktown for "Bacteriological study from one station on the York River".

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## ENGINEERING SECTION

A new engineering building now being constructed at Virginia Polytechnic Institute will house Aeronautical and Chemical Engineering Departments, giving each substantially more space than is now available. R. W. Truitt of the Aeronautical Engineering Department has announced that a Stability Wind Tunnell having a 6-foot throat and capable of reaching air velocities of 360 miles per hour has been obtained from the Langley Field Laboratory of NACA and will be set up as part of this building. In addition, a collection of airplane models worth \$50,000 was obtained from this source. Professors Truitt and Arthur C. Bruce attended the annual meeting of the Institute of Aeronautical Sciences in New York. Professor Bruce has been awarded a fellowship for further study at the Massachusetts Institute of Technology beginning in September.

Frank C. Vilbrandt of the Chemical Engineering Department at Virginia Polytechnic Institute attended the meeting of University Representatives of the Oak Ridge Institute of Nuclear Studies in May. Nelson F. Murphy of the Chemical Engineering Department attended the national convention of the American Electroplater's Society in May as the delegate of the Blue Ridge Branch of the society.

Tilton E. Shelburne of the Virginia Council for Highway Investigation and Research attended meetings of the Performance Rating Panel and of the National Advisory Committee on the AASHO Road Test in April at La Salle, Illinois. Mr. Shelburne is a member of the Steering Committee of the First International Skid Prevention Conference and attended a meeting of this committee in Washington in May. This Conference will be held at the University of Virginia in September and will attract specialists in this field from many foreign countries. Mr. Shelburne also attended meetings of the department chairmen of the Highway Research Board and of presidents and secretaries of District Six of the American Society of Civil Engineers.

Dean Lawrence R. Quarles of the University of Virginia, School of Engineering was the representative of the Governor of Virginia at a meeting of the Advisory Council on Nuclear Energy of the Southern Regional Education Board held in April. He attended the national meeting of the Institute of Radio Engineers in New York in March, as did Orville R. Harris, also of the University of Virginia. Professors Quarles and Harris are on the By-Laws Committee of the newly-formed Virginia Section of the IRE, and Dean Quarles is also on the Nominating Committee.

Otis L. Urdike of the Chemical Engineering Department of the

University of Virginia has served as chairman of the local section of the Society of Sigma Xi during the past academic year. He has been appointed to a sub-committee on Systems Engineering of the American Institute of Chemical Engineers and is working on the organization of a symposium on this subject to be held at a forthcoming meeting of this society. R. M. Hubbard of the Chemical Engineering Department is serving as chairman of a sub-committee of the American Institute of Chemical Engineers on Teacher Recruiting and Placement.

—Robert M. Hubbard, *University of Virginia*

#### PSYCHOLOGY SECTION

William M. Hinton of Washington and Lee University will be teaching at the University of Virginia again this summer and will offer a course at the Virginia Military Institute during the session 1958-1959.

—John K. Bare, *William and Mary*

#### STATISTICS SECTION

The following have completed their requirements for the masters degree in statistics at the Virginia Polytechnic Institute: Mr. W. A. Glenn and Miss Suzanne Glass. Miss Glass is now teaching mathematics at Roanoke College. Ronald E. Walpole completed requirements for the doctorate in statistics at the Virginia Polytechnic Institute and is now head of the Mathematics Department at Roanoke College.

Ralph A. Bradley will attend the Gordon Research Conference in July and he has been invited to present a paper at the ISI meeting in Brussels in September. He will also speak to other societies in Europe.

Recent publications in the Department of Statistics of the Virginia Polytechnic Institute include: (1) Statistical Properties of Inverse Gaussian Distributions. II. by M. C. K. Tweedie, *Annals of Mathematical Statistics*. (2) The Comparison of the Sensitivities of Similar Experiments: Theory. by D. E. W. Schumann and R. A. Bradley, *Annals of Mathematical Statistics*. (3) The Comparison of the Sensitivities of Similar Experiments: Applications. by R. A. Bradley and D. E. W. Schumann, *Biometrics*.

Boyd Harshbarger, President of the Biometric Society, ENAR, will attend the international meetings of the Biometric Society in Ottawa in August. Dr. Harshbarger will also attend the meetings of the Regional Committee on Statistics, of which he is Chairman, at Oklahoma State University in June.

—Clyde Y. Kramer, *Virginia Polytechnic Institute*

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### NOTICE TO CONTRIBUTORS

Contributions to the Journal should be addressed to Robert T. Brumfield, Stevens Hall, Longwood College, Farmville, Virginia. If any preliminary notes have been published on the subject which is submitted to the editors, a statement to that effect must accompany the manuscript.

Manuscripts must be submitted in triplicate, typewritten in double spacing on standard 8½" x 11" paper, with at least a one inch margin on all sides. Manuscripts are limited to seven pages, with the proviso that if additional pages are desired, the author may obtain them at cost. The author may estimate the length of his paper by counting the total number of characters, including blank spaces, and dividing this by 3300. The result is the approximate number of printed pages in the Journal.

Division of the manuscripts into subheadings must follow a consistent plan, and be held to a minimum. It is desirable that a brief summary be included in all manuscripts.

Footnotes should be included in the body of the manuscript immediately following the reference, and set off by a dashed-line above and below the footnote content. Footnotes should be numbered consecutively from the beginning to the end of the manuscript.

Bibliographies (Literature Cited, References, etc.) should be arranged alphabetically according to author. Each reference should include the date, full title of the article, the name of the Journal, the volume, number (optional), pages, tables and figures (if any). For example: "Sniffen, Ernest W. 1940. Cobbles from the Pleistocene Terraces of the Lower York-James Peninsula Va. Journ. Sci., 1 (8): 235-238 1 fig., 1 tab. Reference to the bibliographic citations should not be made by numbers. Instead, using the above citations, where a reference is desired: either "Sniffen (1940)", (Sniffen, 1940: 186)", or "Sniffen (1940) states that . . ."

Explanation of figures, graphs, etc., should be typed on separate pages. All figures should be numbered consecutively beginning with the first text figure and continuing through the plates. If figures are to be inserted in the text this should be clearly indicated by writing "Figure —" at the appropriate place in the margin.

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Galley Proofs and engraver's proofs of figures are sent to the author for correction. Costs of excessive changes from the original manuscript must be defrayed by the author.

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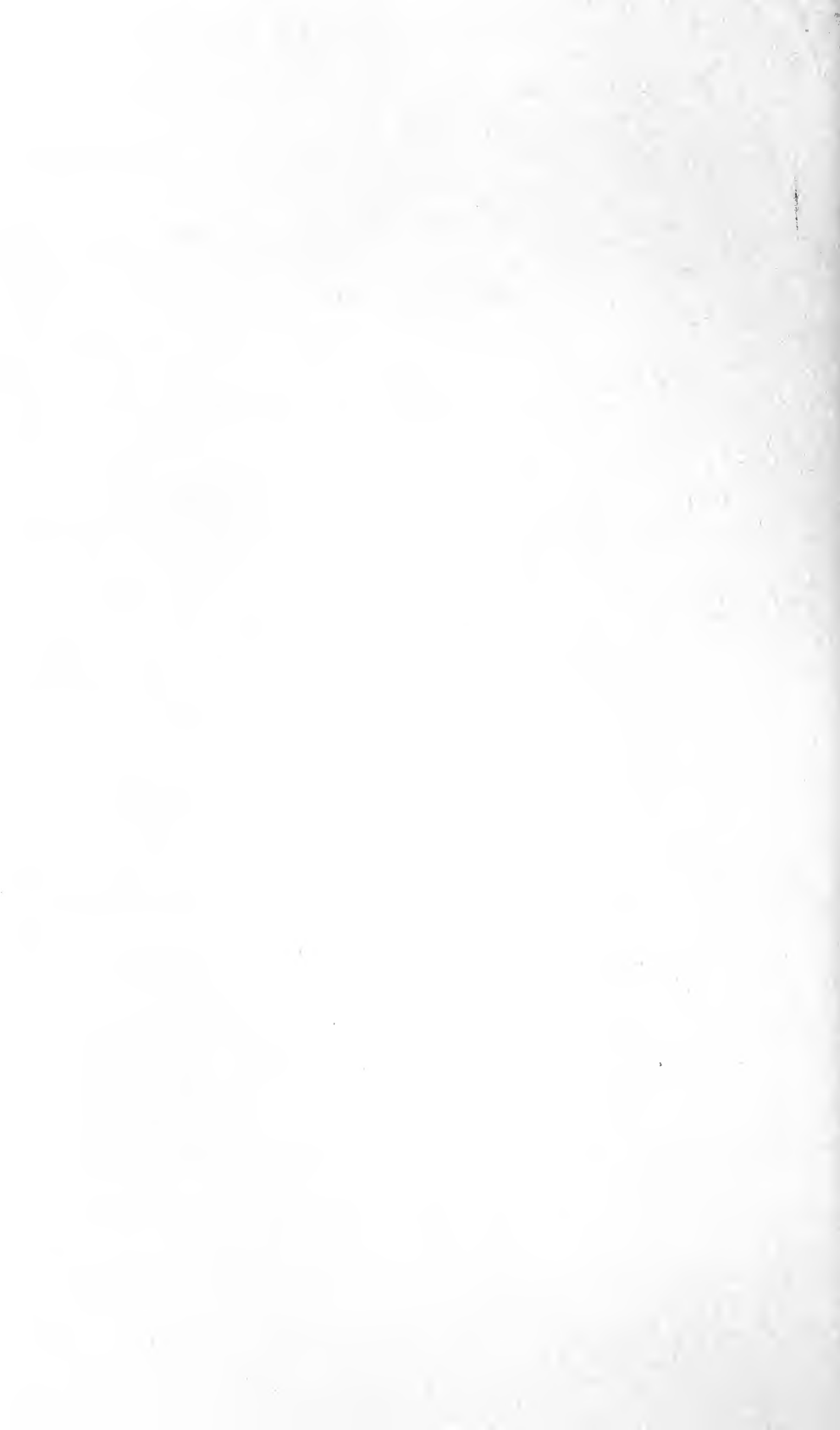
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# THE VIRGINIA JOURNAL OF SCIENCE

A JOURNAL ISSUED QUARTERLY BY THE  
VIRGINIA ACADEMY OF SCIENCE

**PROCEEDINGS FOR THE YEAR**

**1957 — 1958**



Vol. 9, New Series

September, 1958

No. 4



VOL. 9, NEW SERIES

No. 4

SEPTEMBER, 1958

## THE VIRGINIA JOURNAL OF SCIENCE

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SEPTEMBER, BY THE VIRGINIA ACADEMY OF SCIENCE

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Minutes of the Thirty-Sixth Annual Meeting, May 7, 8, 9, 10, 1958	
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Mailed October 27, 1958

# VIRGINIA ACADEMY OF SCIENCE



Proceedings for the Year  
1957 – 1958

MINUTES OF THE THIRTY-SIXTH ANNUAL MEETING

MAY 7, 8, 9, 10, 1958

HOTEL ROANOKE

ROANOKE, VIRGINIA

## Virginia Academy of Science

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*Resolutions:* Nolan E. Rice, Chairman; Everett H. Ingersoll, George W. Jeffers.

*Place of Meeting:* Ernst G. Huf, Chairman; Herbert W. K. Fitzroy, Robert F. Smart.

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*Junior Academy:* Dr. Edward Victor, *Chairman*.

*Registration:* Dr. Richard McKinsey, *Chairman*.

*Public Information:* Dr. Kenneth Lloyd, *Chairman*.

*Commercial Exhibits:* Dr. Bartholomeus Van't Riet., *Chairman*.

*Meeting Rooms and Equipment:* Dr. Starling Reid, *Chairman*.

*Entertainment for Ladies:* To be arranged.

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## MINUTES OF THE COUNCIL MEETING

MAY 8, 1958

Present: R. T. Brumfield, W. S. Flory, Jr., J. C. Forbes, I. G. Foster, T. E. Gilmer, W. C. Guy, E. S. Harlow, Mrs. B. G. Heatwole, W. M. Hinton, H. H. Hobbs, Paul M. Patterson, F. F. Smith, and W. B. Wartman, Jr.

President Guy invited Dr. Boyd Harshbarger and Dr. Sidney Negus to attend Council for their reports as indicated below.

Dr. Negus reported that the Awards Committee had selected the American Tobacco Company for the Academy's Distinguished Service Award. After some discussion it was unanimously approved.

## OLD BUSINESS

With respect to Dr. Forbes' plan to raise funds to make it possible for scientists in small colleges to do research during the summer, Dr. Guy appointed a Committee (Dr. Harshbarger, Chairman, Dr. Cole and Dr. Forbes), to investigate securing these funds. Dr. Harshbarger gave an encouraging report and stated that the first step is to approach various foundations in an exploratory manner before a concrete proposal for funds was formulated. This he plans to do in the near future.

Mr. Smith was asked to report on the outcome of the experiment for auditing the Academy's accounts where the accounts were audited last year by Academy members and this year by public accountants. The question was whether this procedure would save the Academy money. Mr. Smith reported that the saving amounted to \$55 over the two year period. He felt that this was trivial in comparison to the various services rendered by the accountants. He recommended that this experiment be discontinued and that we revert to having the Treasury audited by public accountants every year. This was put in the form of a motion by Mr. Harlow and passed.

Mr. Smith reported that the budget approved by the Finance Committee showed a deficit of \$99 over the expected income. He said the current expenditures were well within the budget and that some accounts always left a balance. Thus he thought that there would be no deficit at the end of the year.

The agenda for the Thursday evening meeting came under discussion. Council thought that Dr. Forbes' proposal to encourage research among college teachers should be brought to the attention of the Academy at this time.

Dr. Brumfield gave a report on the financial condition of the Journal and suggested a number of measures that might be taken in the interest of economy. He said that he was going to have a meeting of the Section Editors later in the afternoon, and Council made no proposals to reduce the deficit spending of the Journal in view of this meeting.

Dr. Guy reported that Mr. Bird had sent him a copy of the By-Laws of the James River Basin Association, and that he would like the opinion of the Council as to whether or not the Academy should associate itself with it. Since Mr. Bird himself had made no recommendation, the subject was tabled upon a motion by Mr. Harlow .

Dr. Guy read a letter he had received from a member of the Academy suggesting that the Academy study, critically, science education in Virginia. Various members of Council recounted several steps the Virginia Educational Association is making to improve science teaching and pointed out various ways in which we were assisting with this undertaking. It was generally agreed that Council should not try to do more now, as our present influence might be jeopardized.

President Guy recommended that the Jamestown number of the Journal, which was on sale at the Jamestown Exposition at 75 cents, be reduced to 50 cents to put it in line with other booklets sold there, if an arrangement can be made to continue its sale during the coming year.

— Paul M. Patterson, *Secretary*

#### MINUTES OF THE ANNUAL ACADEMY CONFERENCE MAY 8, 1958

President Guy presided and called on the Chairman of the Committees of the Academy for their reports.

These reports appear elsewhere in the proceedings. However, attention should be called to Dr. Robert Smart's presentation of an invitation by Herbert W. K. Fitzroy, Administrator of the University Center in Virginia, Incorporated, to meet in Richmond under its sponsorship in 1960. The Academy accepted this invitation.

Dr. Brumfield reported the economies recommended by the editors of the Virginia Journal of Science. This report is attached. A motion was unanimously passed that these economies be implemented.

Dr. Forbes presented his plan to the Academy members which he had formulated to promote research in the state among science faculty personnel during the summer, particularly those in the smaller colleges.

Mr. Smith reported on the AAAS December Council meeting and said

that Dr. Byron Cooper was elected Chairman of the Section on Geology (Vice-President of AAAS).

President Guy welcomed Dr. Raymond Taylor, Executive Director of AAAS, and Dr. Taylor expressed greetings from that Association.

— Paul M. Patterson, *Secretary*

# MINUTES OF THE VIRGINIA ACADEMY OF SCIENCE ASSEMBLY MAY 9, 1958

President Guy presiding, called on Dr. Harshbarger who welcomed the Academy for the host institutions.

President Guy then introduced Dr. Raymond Taylor, Executive Director of AAAS, who presented greetings from that organization.

Miss Zoe Black read the recommendation formulated by the Resolutions Committee, which are attached to these minutes.

Dr. Guy presented the Academy's Distinguished Service Award to the American Tobacco Company. It was accepted for the American Tobacco Company by Mr. Blanton Brunner.

Dr. I. G. Foster, Chairman of the Nominating Committee, reported the following slate:

## OFFICERS:

*President Elect* — William Hinton

*Secretary* — Paul M. Patterson

*Treasurer* — Foley F. Smith

*Assistant Secretary-Treasurer* — William B. Wartman, Jr.

## COUNCIL MEMBERS:

Harry G. M. Jopson

Ralph A. Bradley

These were elected unanimously.

Mrs. Thelma Heatwole announced the recipients of the Teacher Scholarships as follows:

1. The University of Virginia Scholarship — Mrs. Agnes Tanner, of Victoria, with Paul Caldwell, of Woodrow Wilson Junior High School, of Roanoke, as alternate.

2. The College of William and Mary Scholarship — A. B. Niemeyer, of Cradock, and as alternate Mrs. Gertrude Thaxton, of Bedford.

Dr. Robert Brumfield, Chairman of the Research Committee, announced

the following paper was awarded the J. Shelton Horsley Research Prize: "An Electron Microscope Study of the Oxidation of Copper Single Crystals in Aqueous Salt Solutions," by G. Tyler Miller, Jr., and Kenneth R. Lawless, Cobb Chemical Laboratory of the University of Virginia. Honorable Mention was given to a paper entitled "Neutron Diffraction Observation on the Palladium-Hydrogen and Palladium - Deuterium Systems" by James E. Worsham, Jr., of the Department of Chemistry, University of Richmond, M. K. Wilkinson, ORNL, and C. G. Shull, Massachusetts Institute of Technology.

Dr. J. T. Baldwin introduced the speaker of the evening, Dr. Laurence H. Snyder, Dean of the Graduate School of the University of Oklahoma and the incoming President of the University of Hawaii, who gave an outstanding lecture on "Heredity in Human Health and Disease."

After this lecture, President Guy introduced President-Elect Forbes, who concluded the meeting with a few appropriate remarks.

— Paul M. Patterson, *Secretary*

#### MINUTES OF THE COUNCIL MEETING — MAY 10, 1958

Present: Ralph A. Bradley, T. E. Gilmer, W. B. Wartman, Jr., E. S. Harlow, W. G. Guy, W. S. Flory, Jr., W. M. Hinton, R. T. Brumfield, Mrs. B. G. Heatwole, Foley F. Smith, Paul M. Patterson, and J. C. Forbes.

President Forbes presiding, presented Dr. Niemeier of the Engineering Section. He spoke of the George Washington Award the Engineering Section had for Junior Academy members to encourage their interest in engineering. He hoped Council might make this award more generally known to the Academy. His second point related to more active use of members of the Section in Academy affairs. Dr. Niemeier then retired from Council.

It was pointed out that the Bacteriology Section also offered an award to the Junior Academy. After some discussion, Dr. Flory moved that these special sectional awards not only be made at the Junior Academy meeting but that they be announced to the Senior Academy at the Friday evening meeting. The motion carried. This would inform Academy members and be incorporated in the permanent record of the Academy. With respect to Dr. Niemeier's second point, after considerable discussion, Mr. Harlow moved that, on a trial basis, each Section be asked to be represented *ex officio* on Council at each meeting during the next year. This motion was approved. Council felt this should be an exploratory move, and no constitutional change was to be recommended at this time.



Council suggested that the Section Chairman, or his designate, be the *ex officio* member.

Dr. Forbes reported that an invitation for Council to meet at Longwood had been received and inquired the wishes of Council. Dr. Hobbs indicated the availability of the University of Virginia as a meeting place. Mr. Foley Smith moved that the fall meeting of Council be held in Farmville and the spring meeting in Charlottesville. This was approved.

Council's attention now concerned additional methods of reducing the Journal's deficit over and above those approved by the Academy Conference on Thursday evening. It had been suggested at the former meeting by Dr. Harshbarger that the Academy pay for the program reprints furnished at meetings out of funds collected at the annual meeting. He further suggested that the Academy reimburse the Journal for the cost of the reprints of the Jamestown Exposition Number.

Dr. Hobbs moved that the Academy reimburse the Journal for the program reprints for this meeting. This was approved.

Dr. Flory moved that the cost of the reprints for the Jamestown issue of the Journal be reimbursed to the Journal and that such receipts from its sale accrue to the Academy. This was approved.

Mr. Harlow moved that we go on record as giving the thanks of Council to the retiring members of Council for their services and a welcome to the new members of Council.

— Paul M. Patterson, *Secretary*

## TREASURER'S REPORT

## GENERAL FUND

STATEMENT OF CASH RECEIPTS AND DISBURSEMENTS  
FOR THE TWO YEAR PERIOD ENDED DECEMBER 31, 1957

## RECEIPTS — YEAR 1956:

BALANCE ON DEPOSIT — JANUARY 1, 1956 .....\$ 5,137.87

## Revenue:

## Dues:

Regular members .....	\$ 2,159.00	
Collegiate members .....	70.00	
Contributing members .....	270.00	
Sustaining members .....	290.00	
Business members .....	1,300.00	
Delinquent dues .....	127.00	\$ 4,216.00

## Gifts, grants and bequests:

Virginia Junior Academy of Science .....	850.00
General .....	10.00

## Non-revenue:

Advance payment of dues ..... 35.00

## Net collections from meeting,

## May, 1956:

Fees for exhibit space .....\$ 550.00

Registration fees ..... 291.00

Miscellaneous collections ..... 100.30

\$ 941.30

Meeting expenses paid ..... 841.20 100.10

Dividends on stock ..... 119.15

Income from special trust fund .. 110.00

Total Receipts — Year 1956..... 5,440.25

\$10,578.12

## DISBURSEMENTS — YEAR 1956:

## American Association for Advancement of

Science Meeting .....	\$ 209.04
Junior Academy of Science .....	1,362.85
Miscellaneous and general .....	353.34
Postage and express .....	106.20
Printing .....	200.00
Science Talent Search .....	667.85
Stationery, supplies and stenographic service .....	165.50
The Virginia Journal of Science .....	2,018.27
Dr. E. C. L. Miller Award .....	50.00
Major W. Catesby Jones Award .....	10.00

Advance to Research Fund .....	40.00	
Total Disbursements — Year 1956 .....		5,183.05
BALANCE ON DEPOSIT — DECEMBER 31, 1956 .....		\$ 5,395.07

## RECEIPTS — YEAR 1957:

## Revenue:

## Dues:

Regular members .....	\$ 2,375.00	
Collegiate members .....	48.00	
Contributing members .....	310.00	
Sustaining members .....	320.00	
Business members .....	1,000.00	
Delinquent dues .....	88.00	\$ 4,141.00

## Gifts, grants and bequests:

Virginia Junior Academy of Science .....	450.00	
General .....	10.00	

## Non-revenue:

Advance payment of dues .....	209.00	
Net collections from meeting, May, 1957:		

Fees for exhibit space .....	\$ 400.00	
Registration fees .....	280.10	
	\$ 680.10	
Meeting expenses paid .....	522.54	157.56

Dividends on stock .....	91.65	
Income from special trust fund ....	160.00	

Total Receipts — Year 1957 .....		5,219.21
		<u>\$10,614.28</u>

## DISBURSEMENTS — YEAR 1957:

## American Association for Advancement of

Science Meeting .....	\$ 215.75	
Junior Academy of Science .....	1,626.56	
Miscellaneous and general .....	139.73	
Postage and express .....	229.69	
Printing .....	387.35	
Science talent search .....	477.89	
Stationery, supplies and stenographic service .....	215.31	
The Virginia Journal of Science .....	2,085.54	
Dr. E. C. L. Miller Award .....	50.00	
Major W. Catesby Jones Award .....	10.00	

Total Disbursements — Year 1957 .....		5,437.82
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BALANCE ON DEPOSIT — DECEMBER 31, 1957 .....		<u>\$ 5,176.46</u>
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## TABULATION OF REGISTRATION

Hotel Roanoke, May 9-12, 1958

SECTION	MEMBERS	NON-MEMBERS	TOTAL
1. Agricultural Sciences	20	14	34
2. Astronomy, Mathematics & Physics	39	27	66
3. Bacteriology	11	6	17
4. Biological Sciences	85	31	116
5. Chemistry	59	23	82
6. Education	3	9	12
7. Engineering	8	10	18
8. Geology	21	62	83
9. Medical Sciences	18	3	21
10. Psychology	38	17	55
11. Science Teachers	14	14	28
12. Statistics	11	12	23
No Section Preference	17	90	107
Totals .....	344	318	662
Junior Academy of Science Registration .....			209
Total Registration 1958 Meeting .....			871

## FINANCIAL STATEMENT

## VIRGINIA JOURNAL OF SCIENCE

## Operation Statement for the Fiscal eYar

Virginia Journal of Science

May 1, 1957 — April 30, 1958

**RECEIPTS:**

Academy Subsidy — Members .....	\$ 2,075.25
Advertising .....	168.50
Subscriptions .....	630.25
Transferred from Savings Account .....	1,000.00
Miscellaneous .....	2.00
Total of All Receipts .....	\$ 3,876.00

**EXPENDITURES:**

Reprints .....	\$ 185.00
Printing .....	2,810.75
Postage .....	29.20
Stenographic .....	132.67
Freight .....	6.16
Miscellaneous .....	29.74
Total of All Expenditures .....	\$ 3,193.52

**STATEMENT OF CASH ACCOUNT:**

Balance of Cash at Beginning of Year .....	\$ 1,606.68
Total Receipts for Year .....	3,876.00
Total Cash on Hand During Year .....	<u>5,482.68</u>
Less Total Expenditures for Year .....	3,193.52
	<u>2,289.16</u>
Add Cash on Hand (Petty Cash Fund) .....	2.21
Cash per Checkbook — April 30, 1958....	<u>2,291.37</u>
Add Balance in Savings Account .....	<u>1,688.41</u>
Total Cash as of April 30, 1958 .....	\$ 3,979.78

**BILLS OUTSTANDING:**

January 1958 Issue of Journal ....	\$ 1,974.29
Reprints — Dr. Stow .....	16.00
Reprints — Program .....	165.00
Index .....	104.44
April 1958 Issue of Journal .....	719.01
Total Bills Outstanding ....	<u><u>\$ 2,979.14</u></u>

Audited by Willard G. Leeper, May 6, 1958.

## REPORT OF THE VIRGINIA JOURNAL OF SCIENCE

The expense of publishing the JOURNAL is now greater than its income due to increasing printing cost. Every effort must be made to continue publication since the JOURNAL is of value to the membership of the ACADEMY in many ways. A number of economies will be effected during the forthcoming year in an attempt to narrow the gap between cost and income without affecting the usefulness of the JOURNAL. Council and the membership will be kept informed on the problem.

— Robert T. Brumfield, *Editor*

## COMMITTEE REPORTS

## LONG RANGE PLANNING

On October 16, 1957, a subcommittee (Mr. J. C. Holmes, chairman) was appointed for the purpose of making a survey of granting agencies or other possible sources of funds which might support a study of the effectiveness of the Virginia State Science Talent Searches, a problem referred to the Long Range Planning Committee by Council in May, 1957. Mr. Frank Kizer and Mrs. B. G. Heatwole are working with Mr. Holmes on this matter.

Dr. Henry Leidheiser, Jr., represented the Long Range Planning Committee and the Academy at a meeting held October 14 at the Virginia Institute for Scientific Research. Representatives of various engineering societies in the Richmond Area were present and the purpose was to explore the possibility of setting up a coordinating group of a number of engineering societies. Dr. Leidheiser reported on this meeting to Council on October 20, 1957, and recommended that the Academy continue to be represented in these exploratory meetings and that Academy representatives be appointed from the Engineering Section. Dr. Leidheiser continues to maintain contact with the Joint Coordinating Committee of Engineering Societies to learn what role the Academy might play in the proposed organization.

The activities of the Jamestown Exposition Committee were transferred to the Long Range Planning Committee by Council on March 8, 1958. The committee will consider, among other things, disposition of remaining copies of the special Jamestown Issue of the Journal. Suggestions in this regard should be submitted to the chairman.

The chairman wishes to take this opportunity to thank all members of the committee, and of the Academy, for their excellent cooperation during the past three years, and respectively calls attention of the incoming President to the desirability of appointing a new chairman at this time.

— Lynn D. Abbott, Jr., *Chairman*

RESEARCH

During the period May 1, 1957 to May 1, 1958, the following grants were made:

Harry L. Holloway, Department of Biology, Roanoke College, for study of helminthes of wild animals .....	\$ 140.75
George W. Kent, L. V. Heisey, H. G. M. Hopson, C. E. Shull, R. N. Andes, Bridgewater College, for studies on the ef- fects of immediate reenforcement on the acquisition of a rate skill at the college level. ....	\$ 150.00
R. W. King, R. W. Engle, C. I. Rich, N. O. Price, W. W. Scott, W. E. C. Moore, P. C. Holt, E. C. Turner, Depart- ment of Biology, The Virginia Polytechnic Institute, for collecting and study of soils, plants, and insects from Haiti. \$	200.00
William W. Scott, Department of Biology, The Virginia Poly- technic Institute, for research on the phycomycetes of caves. ....	\$ 200.00
Jesse C. Thompson, Department of Biology, Hollins College, for a morphological study especially of the buccal cilia- ture of the holotrichous protozoan suborders Trichostoma- tidae and Hymenostomatidae. ....	\$ 419.50
Total grants .....	\$1,120.25
J. Sheldon Horsley Research Award .....	\$ 150.00
Total Expenditures .....	\$1,270.25
Total receipts 1957-1958 .....	\$1,710.75
Unexpended Balance .....	\$ 440.50

— R. T. Brumfield, *Chairman*

SCIENCE TALENT SEARCH

The thirteenth Virginia Science Talent Search was conducted in coop-  
eration with the National Science Talent Search. Of the one hundred and  
fifty-four high school students who entered, three received National  
Honorable Mention.

Our own reading committee considered all of the Virginia entries and  
selected the top forty-five as finalists to come before interviewing com-  
mittees at the Roanoke meeting of the Academy. The list of fifteen

Winners and those receiving Honorable Mention will be attached to this report. All cooperating colleges and universities have received a list of the finalists. At the conclusion of this meeting they will be sent the list of Winners and Honorable Mentions.

The directors are grateful for the assistance of the following who served on the reading committee:

Jack D. Burke, Mary E. Kapp, E. Clifford Nelson, Billy W. Sloope, J. Doyle Smith, and William E. Trout, Jr.

Thanks are also due to the judges who helped with interviewing the finalists: J. T. Baldwin, Jr., Roger Buck, Jane Bell Gladding, Mary E. Kapp, B. W. Mahoney, David O. Robash, Burke M. Smith, and Robert W. Truitt.

— W. Schuyler Miller and J. C. Holmes, *Co-Directors*

#### VIRGINIA JUNIOR ACADEMY OF SCIENCE

*Junior Officers:* Ashton Rudd, Jr., President; Richard Owen, IV, President-Elect; Elizabeth Cunningham, Secretary-Treasurer.

*Committee Members:* Mrs. Thelma C. Heatwole, Chairman; E. R. Dyer, John F. Hahn, Richard Canham, Susie V. Floyd, E. Sherman Grable, Beatrice Harrington, J. C. Holmes, Franklin Kizer, Reuben McDaniel, Sidney S. Negus, H. Felix Sanders, and D. L. Kinnear.

#### *Committee Meetings:*

Four planning meetings of the Virginia Junior Academy of Science Committee have been held since the last annual meeting.

#### *Activities of VJAS:*

The issues of the JUNIOR SCIENCE BULLETIN have been published and each issue was mailed to approximately 1600 secondary school teachers. Publication of the BULLETIN was made possible by a \$300 contribution from the American Tobacco Research Laboratory. The BULLETIN was printed in the Newport News High School Print Shop under the editorship of Miss Susie V. Floyd, and the direction of Mr. M. L. Thompson. The three issues were planned by the Junior Academy officers.

Membership cards (approximately 8,000), and charters were issued to all clubs and individuals who applied for affiliation. Seventy-eight clubs have been affiliated.



Information on activities was mailed three times during the year to 500 public and private secondary schools.

Six students received financial assistance on the purchase of equipment to use in conducting their research projects. The funds were contributed by Philip Morris, Inc. as a part of its \$750 grant to the Junior Academy.

Five JUNIOR SCIENCE DAYS were held in cooperation with five colleges within the state.

	<i>Students Present</i>	<i>Schools Represented</i>	<i>Projects</i>
St. Paul's College .....	500	42	48
University of Richmond .....	485	27	39
University of Virginia .....	175	19	65
William and Mary .....	92	8	44
Virginia Polytechnic Institute ...	250	21	120
Totals .....	1,502	117	217

The Annual Meeting VJAS was held at the Hotel Roanoke on May 8 and 9. One hundred and twenty-three exhibits which illustrated research projects were qualified at the JUNIOR SCIENCE DAYS for exhibit at the annual meeting.

The guest speaker at the Awards Hour was Andrew E. O'Keeffe, Manager of Tobacco Research, Philip Morris, Inc. Subject: SCIENCE AS A BIOLOGICAL PROCESS. Dr. Laurence H. Snyder, past president, AAAS, and Dean of the Graduate School, University of Oklahoma, spoke briefly to the assembly.

The following awards were announced at the Awards Assembly:

Major W. Catesby Jones — To high school student whose exhibit showed the most outstanding research ability — Mary Lou Myers, Eagle Rock H. S.

E. C. L. Miller — To an outstanding science club of the state — Washington and Lee H. S. Sc. Club, Arlington H. S.

E. C. L. Miller — To an outstanding science club of the state — Thomas Jefferson, Richmond.

Membership American Association for the Advancement of Science — Ashton Rudd, Andrew Lane H. S. and James Biglow, Thomas Jefferson H. S.

Membership in Virginia Academy of Science — Elizabeth Cunningham, York H. S. and Ben Harrison, Newport News H. S.

#### TEACHER SPONSOR SCHOLARSHIPS (Summer)

University of Virginia — Alternate — Mrs. Agnes Tanner, Victoria H. S. and Paul Caldwell, Woodrow Wilson H. S.

William and Mary Scholarships — Alternate — A. B. Niemeyer, Cradock H. S. and Mrs. Gertrude Thaxton, Bedford H. S.

Bacteriology Section Award in Microbiology — Billy Ridenour, Wm. Fleming H. S.

Honorable Mention — Betsy Gilfoyle, York H. S.

#### AWARD

George Washington Engineering Award — Malcolm Alden Lillywhite, Washington and Lee H. S.

#### WINNERS OF THE THIRTEENTH VIRGINIA SCIENCE TALENT SEARCH

Franson, Paul Oscar, III — Washington-Lee H. S., Arlington

Gilmer, Lawrence Earnest — Mount Vernon H. S., Alexandria (Home: Ft. Belvoir)

Mintz, Michael Jerold — Washington-Lee H. S., Arlington

Moulis, Edward Jean, Jr. — Falls Church H. S., Falls Church

Myers, Mary Louise — Eagle Rock H. S., Eagle Rock (Home: Glen Wilton)

Neville, Charles William — Fairfax H. S., Fairfax

Riley, Michael Howard — Washington-Lee H. S., Arlington

Rudd, Ashton C. III — Andrew Lewis H. S., Salem (Home: Roanoke)

Snider, Arthur David — Thomas Jefferson H. S., Richmond

Snider, James Randolph — Fairfax H. S., Fairfax

Tarrant, Stephen Werth — John Marshall H. S., Richmond

Taylor, Albien D. — Washington-Lee H. S., Arlington

Terry, Robert Meredith — Halifax County H. S., South Boston

Tetter, Lorena Elizabeth — Washington-Lee H. S., Arlington

Vogel, Barbara Adele — Thomas Jefferson H. S., Richmond

*Honorable Mention*

- Biglow, James William — Thomas Jefferson H. S., Richmond  
Cocke, Charles Lewis, Jr. — Jefferson Senior H. S., Roanoke  
Cross, Allen Rawles — Andrew Lewis H. S., Salem  
Davis, Charles Young — Washington-Lee H. S., Arlington  
Diener, Betty Jane — Washington-Lee H. S., Arlington  
Donovan, Kerry Lane — Washington-Lee H. S., Arlington  
Doran, Stanley Wilson — McLean H. S., McLean (Home: Falls Church)  
Dudley, Ronald George — Mount Vernon H. S., Alexandria (Home: Ft. Belvoir)  
Eastwood, James Albert — Andrew Lewis H. S., Salem (Home: Roanoke)  
Gammon, Robert W. — Wakefield H. S., Arlington  
Garner, Francis Albert — Mount Vernon H. S., Alexandria (Home: Ft. Belvoir)  
Gildes, Robert W. Lee, Jr. — Lane H. S., Charlottesville (Home: Cobham)  
Graybeal, Frederick Quincy, Jr. — Marion H. S., Marion  
Huffman, Arthur Hurn — Blacksburg H. S., Blacksburg  
Keith, John Elmer — Washington-Lee H. S., Arlington  
Kelly, Leonard William, Jr. — Marion H. S., Marion  
McIlwaine, William Travis — Virginia H. S., Bristol  
McCrary, Roy Allison — Granby H. S., Norfolk  
More, Thomas Kittrell — Falls Church H. S., Falls Church  
Neale, Michael — Washington-Lee H. S., Arlington  
Olson, John Whittemore — Washington-Lee H. S., Arlington  
Plunkett, Roy Wills, Jr. — Farmville H. S., Farmville  
Soper, Robert Arthur — Halifax County H. S., South Boston  
Starbird, Edward Alfred — Washington H. S., Arlington  
Steinecker, Ronald Alan — Washington-Lee H. S., Arlington  
Thomas-Peter William — Bedford H. S., Bedford  
Thurber, Bert Henry — Washington H. S., Arlington  
Winston, John Austin — Granby H. S., Norfolk  
Woolisy, Frank Edward — James Monroe H. S., Fredericksburg  
Yens, Robert Christian — Mt. Vernon H. S., Alexandria (Home: Ft. Belvoir)

*Club Exhibits*

First place: Thomas Jefferson High School. "Virginia". Sponsored by Miss Virginia C. Ellett.

Second place: Victoria Junior Science Association. "Blood Donor Registry". Sponsored by Mrs. Agnes V. Turner.

Third place: Woodrow Wilson Junior High School Science Club. "Looking at General Science". Sponsored by Paul Caldwell.

Honorable mention: Maggie Walker High School. "A Study of the Theory of Probability". Sponsored by Mrs. Beatrice Harrington.

*Biology Exhibits*

First place: Ben Harrison, Newport News High School. "Growth Mechanics of the Gastropod Shell". Sponsored by Mrs. Frances Nettles and Miss Susie V. Floyd.

Second place: James Baird, William Fleming High School. "The Study of Anoxia as a Cause of Congenital Deformities". Sponsored by Mrs. Ruth B. Painter.

Third place: Mary L. Myers, Eagle Rock High School. "Endocrinology — Effect of the Hormones". Sponsored by William W. Cash, Jr.

Honorable mention: David Hambrick, William Fleming High School. "Skin Grafts on *Albus musculus*". Sponsored by Mrs. Ruth B. Painter.

James Meem, Albemarle High School. "Evolution in Ants". Sponsored by Kenneth Lindsey.

Robert E. Mosby, Jr., J. P. Burley High School. "Mammary Fibroadenoma of the Rat". Sponsored by Harold T. Green.

Billy Ridenour, William Fleming High School. "Induced Mutations of *Escherischia coli* by Metabolic Substitution". Sponsored by Mrs. Ruth B. Painter.

*Physics Exhibits*

First place: Warren Bass, McLean High School. "Experiments in Nuclear Physics with a Homemade Atom Smasher". Sponsored by General W. Rumbough.

Second place: James W. Biglow, Thomas Jefferson High School. "Effect of Heat and Light on Transistors". Sponsored by Virginia C. Ellett.

Third place: Nelson Bonn, Jr., Pulaski High School. "My Experimental Recording Medium and Recorder". Sponsored by J. S. Fowler.

Honorable mention: Phillips Bradford, Fairfax High School. "Probability". Sponsored by R. A. Williams.

### *Chemistry Exhibits*

First place: Adele Vogel, Thomas Jefferson High School. "Growth of Crystals". Sponsored by Virginia C. Ellett.

Second place: Barry Barnes, Fred Case and Penny Stone, York High School. "Calcium Carbonate and Chloride Concentration of York County Well Water". Sponsored by Elizabeth Charlton.

Third place: Patricia Lindsey, Booker T. Washington High School. "Study in Corrosion". Sponsored by J. L. Perry.

Honorable mention: Betsy Wetmore, Hampton High School. "Crystal Forms of Chemicals and Minerals". Sponsored by D. M. Rose.

Frances Garner, Mount Vernon High School. "Effects of Acid, Alkali and Solvents on Concrete Solvency". Sponsored by O. R. Layman.

### *Unclassified*

First place: Larry E. Gilmer, Mount Vernon High School. "A Device for the Induction of Fluorescence in Minerals through the Use of combined Ultraviolet and Infrared Radiations". Sponsored by O. R. Layman.

Second place: Albert Moss, Maggie Walker High School. "Graph of the Complex Roots of the Cubic Equation". Sponsored by Mrs. Beatrice Harrington.

Third place: Carl Rowles, Halifax County High School. "Celestial Photography". Sponsored by Jean Blackwell.

Honorable mention: Fred Anderson and Jim Small, McLean High School. "Seismograph", Sponsored by Mrs. Martha Walsh. John Hicks, Maggie Walker High School. "Testing a Statistical Hypothesis". Sponsored by Beatrice Harrington. Dorn Schmidt, McLean High School. "An Astronomical Telescope". Sponsored by Mrs. Martha Walsh.

## JUNIOR ACADEMY OFFICERS FOR 1959

*President:* Richard Owen, Thomas Jefferson H. S., Richmond

*President-Elect:* Mike Nickelsburg, Washington-Lee H. S., Arlington

*Secretary:* Nancy Stoller, Newport News H. S.

## VIRGINIA FLORA

The annual report consists of the activities of individuals of the Committee. Illustrated lectures are given before groups and at summer camps. Dr. Patterson continues his studies of the Bryophytes. Prof. Freer has prepared a second paper on the flora of the northern Blue Ridge in Virginia. W. H. Lewis, formerly with Dr. Flory, has prepared a paper on the genus *Rosa*. Dr. Massey continues work on a State flora and developing a State herbarium. He is now developing a specific study of the grasses. Mr. A. L. Eiser, working with Dr. Massey, is developing a study of the shrubs of the State. A large number of plants are received from over the State for identification. *Bunis eruroides* has been found in Prince Edward County, the first record in the U. S. since 1877. *Calepina irregularis* is also a new record.

The following publications relative to the State flora may be secured from *Chairman on Virginia Flora, Box 95, Blacksburg, Virginia*: Native Grapes; Willows of Virginia; Poisonous Plants; Legumes in Virginia; Farm Weeds; Virginia Ferns and Fern Allies; Orchids in Virginia; The Vegetation and Floristics of Bull Run Mountain, Virginia; Evergreen Shrubs, Vines and Ground Cover Native in Virginia; Merriman's Flora of Richmond and Vicinity. The latter is priced at \$1.00. The other publications are *gratis*.

— A. B. Massey, *Chairman*

## RESOLUTIONS

Be it resolved:

1. That the members of the Academy are deeply indebted to the outgoing president, Dr. William G. Guy, and to the other officers, both General and Sectional, for their devoted attention to the affairs of the Academy.
2. That the members of the Academy extend their thanks and appreciation to all those who worked and planned for the success of this meeting, especially;

The members of the Local Committee on Arrangements, under

the General Chairmanship of Dr. Boyd Harshbarger, for their effective planning.

Mr. George L. Denison and Mr. Kenneth R. Hyde, Associate Managers of the Hotel Roanoke, for their kind and efficient cooperation.

All the members of the staff of the Hotel Roanoke, for helping us enjoy our stay.

The sponsoring hosts for this meeting: Hollins College, Roanoke College, Virginia Polytechnic Institute, American Viscose Corporation, General Electric Company, Norfolk and Western Railway, and the Veterans Administration Hospital.

St. Andrews School and the Times-World Corporation, for supplying meeting places for two sections.

And Heironimus of Roanoke for presenting a Tea and Fashion Show for the visiting ladies.

And furthermore that the Secretary be instructed to send a copy of this Resolution to those mentioned in it.

3. That the members of the Academy note with sorrow the loss by death of these members;

Dr. Marcellus Stow, a past President of the Academy, who was at the time of his passing away a member of the Resolutions Committee. Captain John Flexner, Dr. E. P. Johnson, Dr. John C. Layman, Dr. Sidney Trattner, and Dr. Paul Burch. And furthermore, that the Secretary be instructed to send a copy of this Resolution to the family of each deceased member.

4. That a copy of these Resolutions be spread upon the minutes of this meeting.

— Zoe Black and Nolan Rice, *Co-Chairmen*

#### PLACE OF MEETING FOR 1960

Colonel H. W. K. Fitzroy, administrator of the University Center in Virginia, wishes me to announce that the Center extends a cordial invitation to the Virginia Academy of Science to hold its 1960 meeting in Richmond, Virginia, during the month of May.

— Ernst Huf, *Chairman*

#### MEMBERSHIP

A comparison of the membership rosters of the Virginia Academy of Science and the Virginia sections of the American Chemical Society show-

ed that 867 chemists and/or chemical engineers were not enjoying the benefits of the Academy. Accordingly, letters were sent to these non-members, and the response, we believe, would warrant the undertaking of similar future endeavors.

## New memberships:

Regular	124
Contributing	5
Sustaining	0
Student	9
Business	1
	-----
Total	139

## Members resigned or dropped:

Regular	65
Student	4
Business	1
	-----
Total	70

The secretary reported that approximately 100 new memberships had been received through the first four months of 1958. Credit for many of the new memberships should go to the 1956-1957 membership committee.

— R. A. Clayton, *Chairman*

## SCHOLARSHIP

Twenty-four students with aptitudes for scientific careers have been advised during the year by members of the Academy's Scholarship Committee. All concerned received college scholarships either directly or indirectly from aid given them.

Senior members of the Academy and especially high school and college teachers are urged to act independently as individual members of this scholarship committee. Often just one person interested in a high school senior talented in scientific subjects can make it possible for him to secure a college education at a cost within his means. This is one of the best and most satisfying contributions that any individual member of the Academy can make.

— Sidney S. Negus, *Chairman*

## EDUCATION

The principal work of the Education Committee in 1957-58 was following through on matters which were initiated previously. No formal meeting was held but individual members were called upon for consultation by the State Department of Education and by other groups for talks and advice.

Following the issuance of the Virginia Advisory Legislative Council's



report on Education of Scientists, Engineers, and Specialists Dr. Davis Y. Paschall recommended to the State Board of Education the appointment of an advisory committee to the State Department of Education consisting of scientists, engineers and educators. The recommendation was accepted and the Committee was appointed in February, 1958. Three members of the Academy's Education Committee were named to this advisory committee, Messrs. James W. Cole, Jr., Edward S. Harlow, and your chairman. A program of broad scope has been outlined and will aid materially in advancing and improving science and mathematics education in Virginia.

The Virginia State Chamber of Commerce has been active in education matters for a number of years through their Committee on Education. Your chairman was appointed to this committee for 1957-58 and served on the subcommittee designated to study demands of the future.

— E. D. Crittenden, *Chairman*

## MINUTES OF THE SECTION MEETINGS

### AGRICULTURAL SCIENCES

#### 1. AVAILABLE CALCIUM AND MAGNESIUM IN SOILS OF VARYING TEXTURE. W. W. Moschler; *Virginia Agricultural Experiment Station*

Increases in soil pH and available calcium and magnesium were determined at thirteen "on the farm" rate of liming experiments. The lighter, sandier soils contain approximately one half as much available calcium and magnesium as do the heavier, more clayey soils at the same pH level. Rumford loamy fine sand containing 773 pounds per acre of available calcium and magnesium when near neutrality and Davidson clay loam containing 3032 pounds when near neutrality represent the extremes for the soil types studied. The portion of the exchange capacity occupied by calcium and magnesium averaged approximately 60% at neutrality, for most soil types. Individual soil types ranged from 40 to 70%, the lighter soils generally being the highest and the heavier soils the lowest.

#### 2. THE EFFECT OF INITIAL WEIGHT AND AGE UPON THE MOLYBDENUM-INDUCED RAT GROWTH.

Lynn Brinkman and R. F. Miller; *Virginia Agricultural Experiment Station*

Experiments with laboratory rats indicate that animals which are of greater weight or age at the beginning of molybdenum addition to the diet are less susceptible to the growth inhibiting effects of molybdenum than those animals lighter or younger. Attempts to further verify and prove this indication have not been successful as yet. The difficulty

may be due to differences in breeding and background of the rats or to differences in body stores of copper, an important compound in molybdenum metabolism. Analyses of liver copper show very much variation in the rats purchased from different companies and there are also pronounced differences between rats from the same company. In order to study properly this trace mineral work in the future, it will be necessary to use rats with a more standardized background.

### 3. THE EFFECT OF 12 ESSENTIAL NUTRIENTS SPRAYED ON VIRGINIA 56R PEANUTS AT FLOWERING STATE.

D. L. Hallock; *Virginia Agricultural Experiment Station*

The effect of nutrient foliar sprays on peanut peg and nut development was studied. Four weekly applications of solutions, each containing a particular nutrient, were made on widely spaced peanut plants during July 1957. Calcium, potassium, magnesium, manganese, zinc, and copper were applied as acetates, and phosphorus, boron and molybdenum as acids. Urea, lithium sulfate and ferric citrate were the other nutrient sources. The peanuts were harvested in the latter part of October.

Although the treatments were replicated 10 times, no significant (0.05 level) differences in yield or quality of peanuts were found among treated and untreated plants. However, a summary of certain data which indicate the production potential of single plants grown under field conditions is noteworthy.

Each plant produced an average of 1103 pegs from which 592 peanuts in various stages of development had formed by harvest time. Of these, slightly more than 400 peanuts, including 347 fancy-sized peanuts, were mature. The mean yield of mature peanuts per plant was 1.1 pounds. By the end of the growing season, the vines of each plant covered a circular area approximately five feet in diameter.

These peanuts were grown on Woodstown loamy fine sand high in fertility. The results of this study indicate that, in general, peanuts may obtain adequate nutrition from fertile soils.

### 4. SHIFT IN NITROGEN METABOLISM DURING THE LIFE OF A CELL.

R. R. Schmidt, R. W. Krauss, and K. W. King; *Virginia Agricultural Experiment Station*

Cultures of the alga *Chlorella* have been synchronized and examined for metabolic shifts during a complete life cycle.

Measurements of dry weight, total cell nitrogen, protein nitrogen, and nitrate uptake throughout a synchronized life cycle confirmed the results of Prescott and others in that cell growth was found not to be autocataly-

tic. The increase in dry weight did not appear to be correlated with increases in total cell nitrogen or protein nitrogen. Phosphate uptake was greatest just prior to and during mitosis suggesting its conversion to polyphosphate which served as an energy and phosphate source for the synthesis of nucleoproteins.

Observation of a nitrogen fraction which was extractable with distilled water immediately before and for a short time during mitosis suggested an accumulation of nucleoprotein precursor. It may, however, represent a change in cell permeability resulting from deletion of calcium ions from the cell membrane which increases permeability and allows loss of normal intracellular constituents.

A volatile nitrogen compound was evolved from the culture during mitosis. Its chemical structure and significance are being investigated.

Evolution of the volatile nitrogen compound during mitosis, pre-mitotic uptake of phosphate, and transitory appearance of water-extractable nitrogen represent indications of marked metabolic fluctuations in the dynamics of cell development.

5. THE EFFECTS OF GONADOTROPINS AND PROGESTERONE ON THE VARIOUS REPRODUCTIVE PHENOMENA OF THE EWE.

J. W. Gossett, C. S. Givens, Jr., and R. C. Carter; *Virginia Agricultural Experiment Station*

Ovulation rates may reduce reproductive efficiency of sheep. This investigation studied the use of gonadotropic hormones to increase ovum production and thereby produce higher lambing rates.

Two groups of ewes, one aged one young, were divided into three sub-groups each and treated with 600, 800 and 1000 I.U. of P.M.S. during the progestrous period. The old ewes were further subdivided into five groups: one group was slaughtered 48 hours after breeding to determine ovulation and fertility rates. The remaining groups received 0, 25, 50 and 75 milligrams of progesterone each week until 40 days after breeding. The twelve 48-hour ewes ovulated an average of 1.75, 2.25, and 5 ova for the respective treatments. Fertility rates were comparable for all ewes studied in this group. The 40-day ewes exhibited an average of 2.14, 2.89 and 2.38 corpora lutea and an average of 1.71, 1.89, and 1.75 embryos for the respective treatments. Progesterone therapy appeared to increase embryonic mortality.

The young ewes completed the gestation period and averaged 1.44, 1.55 and 1.77 lambs. Considering stillbirths, these averages were changed to 1.33, 1.55 and 1.55.

6. THE INFLUENCE OF CALCIUM, PHOSPHOROUS AND COPPER LEVEL UPON THE GROWTH OF THE RAT.

Russell F. Miller; *Virginia Polytechnic Institute*

Weanling albino rats were fed for five or six weeks. The basal ration was a 12% casein basal without a source of inorganic sulfate. The addition of 1.25%  $\text{Ca}_3(\text{PO}_4)_2$ , 1.25%  $\text{CaCO}_3$  or 1.39%  $\text{K}_2\text{HPO}_4$  caused a growth depression. Extra copper (9.6 ppm) will improve the growth of these animals.

We have also noticed that liver copper concentration is depressed when extra Ca,  $\text{PO}_4$  or  $\text{Ca}_3(\text{PO}_4)_2$  is fed. We plan more work and plan to start work with hogs in an effort to study this effect.

7. NEW CROP PESTS THREATENING VIRGINIA.

C. R. Willey; *Virginia Department of Agriculture*

Virginia, with several hundred insect pests and plant diseases, certainly has her share of crop pests. Her 500 mile expanse across the continent from the sea to the mountains; truck-line highways; long shore line and port; her range of climate and widely diversified agriculture make her vulnerable to infestation by many dangerous insects and diseases which virtually surround her.

The White-fringed beetle, Imported fire ant, European chafer, and Gypsy moth (insects), the Soybean cyst nematode and Golden Nematode (diseases) are microscopic eelworms; and the witchweed, a parasitic weed, are all dangerous pests brought into the United States from other countries which, should they get into Virginia, could cause incalculable damage to our crops and forests and make it necessary to spend hundreds of thousands of dollars to combat them.

It is the duty of the crop pest section of the Division of Plant Industry to try to keep these pests out of Virginia by quarantines, inspection and surveys. This function is a year around operation with emphasis on the summer season, using trained extra help, when the pests are most active and can be more easily detected.

8. THE USE OF TETRAZOLIUM TO EVALUATE THE VIABILITY OF SEED PEANUTS.

H. L. Smith and T. G. Copeland; *Virginia Department of Agriculture*

There is a vital need for a quick-test to check germination. The use of 2-3-5 triphanyl tetrazolium chloride shows great promise of fulfilling this need.

This test is made by soaking the seed in a solution of the chemical

which stains any tissue showing life. The embryo area of the seed stains a clear red color if healthy. Dead tissue does not stain. Bruised areas stain a dark red color until they deteriorate to the point of death, after which they do not stain. The location and degree of damage is a determining factor in the evaluation of the seed life.

During the spring of 1958, workers of the Virginia Department of Agriculture, using a technique obtained from Dr. R. P. Moore, Professor of Crop Stands at the North Carolina Agricultural Experiment Station, applied this chemical test to approximately 200 samples of peanuts in an attempt to evaluate its usefulness. The samples tested by this method compared favorably with the standard test. However, due to the questionable seed, this test is not considered competent for labeling purposes. Much experience is needed to develop a high level of perfection in determining seed viability by means of tetrazolium tests.

#### 9. REGULATING FERTILIZER-PESTICIDE MIXTURES.

Maurice B. Rowe, III; *Virginia Department of Agriculture*

The sale and distribution of fertilizer-pesticide mixtures containing eight pounds of Aldrin or Heptachlor per ton for use on food crops, when properly registered, packaged and labeled, is permitted by the Virginia Department of Agriculture.

The permission for registration in 1958 applies only to the formulations of fertilizer-Aldrin or Heptachlor mixtures recommended by the Virginia Agricultural Experiment Station for the control of the Southern Corn Root Worm attacking peanuts, or for the control of the Southern Corn Root Worm, Seed Corn Maggot and Wiseworms attacking corn, and only to those fertilizer grades recommended for peanuts and corn.

The mixture is subject to registration, labeling provisions and inspection and analysis under both the Virginia Fertilizer and Economic Poison Laws. Labeling procedure is simplified to permit a combination fertilizer-pesticide label and inter-change of labels for different grades of fertilizer.

The demand for fertilizer-pesticide mixtures has increased due to economics in distribution and application convenience. Experimental work is being conducted to determine feasibility of additional mixtures for farm crops.

The sale of specialty fertilizers containing pesticides for use on non-food crops is permitted, provided they comply with all regulation and label requirements.

# 10. RESOURCES NEEDED IN VIRGINIA AGRICULTURE IN THE DECADE AHEAD.

Carl W. Allen; *Virginia Agricultural Experiment Station*

This is a report of work to be done. To start, the procedure will be to determine or estimate the demand for agricultural products ten years from now, and then with specified techniques of production, determine the quantity of resources which will be needed to attain the output of products needed.

Several models (structural equations) of the agricultural sector of Virginia's economy will be constructed relating total output and total input. The first of these will be simply that total output is a function of land, labor and capital now being used. Making use of this model, future output of agricultural products in Virginia will be projected under static assumptions (no change in technology, price conditions, quantities of resources, etc.). This projected output will be compared with the revised or modified demand estimates and will allow computation of the first approximations of resources needed.

Later models will allow estimates of needed resources with new technology and various rates of adoption. Still further refinements are expected to give estimated resource needs with alternative levels of economic activity, competition with other areas, competition with other industries and substitution between products.

# 11. USE OF INFRA-RED FOR CONDUCTING REGULATORY CHEMICAL ANALYSES OF PESTICIDE PRODUCTS.

Boyd L. Samuel; *Virginia Department of Agriculture*

The use of infra-red in supplementing the classical chemical methods in the analysis of pesticides was described. Most of the chlorinated pesticides that commonly have been determined by the nonspecific chlorine methods can be identified by infra-red and often determined quantitatively also. Related materials and breakdown products were found generally not to interfere if the proper absorbance bands were selected for reference.

In many cases infra-red can be used to determine quantitatively mixtures of chlorinated compounds which hitherto have been difficult to analyze. For example, DDT and Aldrin; DDT and Dieldrin; DDT and Methoxychlor; DDT and Captan; and other mixtures have been determined successfully. Since the infra-red spectrum is unique for each compound, it is a quick and accurate means of identifying organic pesticide materials.

These advantages combine to make infra-red an extremely valuable tool in the analysis of pesticides products. This is especially true when it is used in conjunction with the usual chemical procedures.

12. EFFECT OF AMINO ACIDS IN THE RATION ON GROWTH PATTERN AND MUSCLE DEVELOPMENT IN THE PIG.

C. C. Brooks and H. R. Thomas; *Virginia Polytechnic Institute*

Weanling pigs were fed peanut oil meal, corn, alfalfa rations fortified with vitamins, minerals and antibiotic. In addition Lot 2 received .5% L-Lysine HCL in the ration, Lot 3 received .5% lysine + .3% methionine, Lot 4 received 2% blood meal and Lot 5 received 5% fish meal. A positive control received a ration of soybean oil meal, corn and alfalfa.

Each supplements except lysine alone resulted in significantly faster gains. Lysine added alone resulted in rapid, early growth, but depressed growth as pigs grew older. Adding methionine overcame this depressing effect. Similar growth patterns resulted from natural sources of these amino acids, namely blood meal and fish meal. Pigs receiving no supplement to the basal ration gained very slowly in the early part of the test, but were gaining satisfactorily before reaching 200 number.

13. CHECKING VARIETY CLAIMS ON OATS, BARLEY, AND SOYBEANS BY LABORATORY AND FIELD TESTS.

J. W. Midyette, Jr., H. L. Smith, and T. G. Copeland; *Virginia Department of Agriculture*

It is the duty of our Division to check the accuracy of varietal labeling of seed offered for sale in the state, and to require that any mislabeling be corrected. Trueness to Variety field tests have been used for this purpose for several years. However, when discrepancies are found in the field, the seed represented usually has been sold.

A laboratory test, based on detailed seed characteristics that have been correlated with field plantings, is being used for oats, barley, and soybeans. Although it has limitations, mislabeling of varieties currently popular in Virginia can usually be detected by this test. Its main advantage is that it gives varietal information before the seed is planted.

The laboratory test this past season revealed the following percentage of inaccurate varietal claims: regulatory oat samples, 61½%; service oat samples, 25%; regulatory barley samples, 11½%; service barley samples, 10%; regulatory soybean samples, none; service soybean samples, 121½%.

Mislabeled lots are required to be sold without a varietal claim. Service samples represent potential commercial lots. All laboratory determ-

inations have been verified by field tests. However, several discrepancies found in the field had not been detected in the laboratory.

14. THE INFLUENCE OF AGE, SEX AND SEASON OF BIRTH OF CALF, AND AGE OF COW ON PREWEANING GROWTH RATE AND TYPE SCORE OF BEEF CALVES.

T. J. Marlowe and J. A. Gaines; *Virginia Agricultural Experiment Station*

Data for this study were taken from the performance records of 4,166 calves tested on 66 farms of Virginia breeders over a four-year period, 1953-1956, inclusive. All calves were weighed and scored for type between 90 and 300 days of age.

Least squares estimates of influence enumerated in the title indicate that: (1) Age of calf had little influence on daily gains up to 240 days of age, but had a greater effect on type score. (2) Sex of calf had a marked effect on growth, but only a small effect on type score. (3) Season of birth was an important source of variation in both growth rate and type score. (4) Age of cow was the most important source of variation studied. Both growth rate and type score increased with age of cow up to 6 years, remained fairly uniform from 6 to 10 years, and decline thereafter. (5) Variation in growth rate attributed to sex of calf, season of birth, and age of dam appeared to be of sufficient magnitude to justify the use of correction factors for these effects.

The constants obtained were used to adjust performance records of 1957 calves and found to be quite satisfactory.

15. USE OF SOIL SURVEY MAPS AND SOILS INFORMATION AS AN AID IN TAX ASSESSMENT IN FAIRFAX COUNTY, VIRGINIA.

C. S. Coleman; *Virginia Agricultural Experiment Station*

The rapid change of Fairfax County from a predominantly agricultural county to an urban county has increased land values many times in every part of the County.

Values have shifted from the ability of farm land to produce crops, to their suitability for home sites and business establishments. Satisfactory percolation tests are required on all building lots before a building permit can be obtained. The ability of a soil to take water and allow it to pass through its profile at a satisfactory rate can and has been measured for each soil in Fairfax County. A percolation rating has been assigned to each soil based on actual field tests.

The assessor by using the soil type maps in conjunction with his tax maps can determine a percolation rating for every tract of land, thus enabling him to make a more realistic equitable land assessment.



In that part of the County that is still agricultural, the soils information based on the productive potential of the soils on each farm will be used as one of the factors in arriving at a fair and equitable assessment for each farm.

This is the first time in Virginia that soils information has been used as an aid in tax assessment.

16. SOME FACTOR AFFECTING THE OPTICAL DENSITY OF ACETONE EXTRACTS OF FRESH FECES.

C. G. Noblitt and W. A. Hardison; *Virginia Agricultural Experiment Station*

The effect of light on the optical density of acetone extracts of fresh feces was studied. It was observed that exposure of the extracts to light resulted in an immediate increase in the optical density, the increase being proportional to the light intensity. Extracts kept in the dark remained stable for about 5-6 hours after which a marked increase in optical density was observed. Most of the increase was apparent within the first 50 hours following extraction. From this time to 200 hours after extraction, the rate of change in optical density was not appreciable. The maximum increase in optical density amounted to approximately 18%. Extracts exposed to 14,000 F.C.M. immediately after extraction and then kept in the dark showed no increase in optical density even after 200 hours. These observations indicate that precaution should be taken to keep light at a minimum both during and after preparation of the extracts and that readings of optical density be made within 5-6 hours of extraction. It is also indicated that the extracts may be stabilized by exposure to large quantities of light.

17. COST OF PACKING APPLES IN BUSHEL UNITS AS AFFECTED BY DIFFERENT TYPES OF EQUIPMENT AND SCALE OF OPERATION.

Albert W. Graybill; *Virginia Polytechnic Institute*

A study of a selected group of apple packing houses in Virginia revealed wide variations in work methods, types of equipment and scale of operation in packing apples.

Gravity conveyors were the most widely used equipment for receiving of apples in the smaller plants, but this study indicated the hand-clamp truck was the most economical and efficient method of performing this operation in plants having insufficient volume to warrant the use of industrial fork-lift trucks.

Two basic types of equipment are used in Virginia for sizing apples: dimensional sizer and weight sizer. Dimensional chain sizers are cheaper,

have a greater capacity than weight sizers, but are not as desirable for some varieties of apples.

More Northwestern boxes were packed per man hour from rotating tubs but more bushel baskets were packed from packing bins than any other equipment. Less time was required in lidding Northwestern boxes by hand and the nail dispenser than with the nail dispenser and box-lid clamp.

Labor cost per bushel was essentially the same for plants packing 10,000 bushels as for those packing 100,000 bushels. More important than size of operation on labor cost were types of equipment, work methods, plant layout and supervision of crews.

#### 18. EFFECTS OF LIME ON THE MINERAL COMPOSITION OF SOYBEAN FOLIAGE.

N. O. Price, W. W. Moschler and W. Kroontji; *Virginia Agricultural Experiment Station*

Different levels of lime has little effect on the major element (N, P, K, Ca and Mg) content of soybean foliage. However, the minor element (Cu, Co, Mo, Mn and Zn) content of the foliage show great differences due to various lime applications. The lower levels of lime bring about the greatest change in the minor element content of the foliage. Soil type is also an influencing factor effecting the mineral composition of plants.

#### 19. HISTORY AND POTENTIAL USE OF GIBBERELIC ACID.

Virgil H. Young, Jr., *Merck & Co., Inc.*

The effects of gibberellins on plant growth were first reported in Japan in 1898 as a disease of rice. About 1930, it was demonstrated that sterile culture filtrates of the fungus would produce the "tall growth" characteristic of the disease on rice plants. In 1954, fermentation techniques for producing the gibberellins were reported almost simultaneously by British and U.S. scientists. Research has already yielded several practical and economical agricultural uses for the gibberellins. Field applications are now being made on potatoes, grapes, cotton seed and celery. Several other promising uses are being currently tested on a large scale.

## SECTION OF ASTRONOMY, MATHEMATICS, AND PHYSICS

1. DESIGN AND EVALUATION OF A CADMIUM SHIELD OF THE VIRGINIA POLYTECHNIC INSTITUTE EXPONENTIAL PILE<sup>1</sup>A. DeVolpi and A. Robeson; *Virginia Polytechnic Institute*

A cadmium-aluminum shield is built around the V.P.I. exponential pile; (1) to establish boundaries opaque to an influx of thermal neutrons from outside the pile, (2) to secure the natural-uranium slugs from pilferage, (3) provide additional biological protection, (4) to restrict access to the neutron source, and (5) to protect the assembly from dust and dirt. The aluminum is required to provide structural strength. Access through doors on the four sides is afforded for experiments and loading; an opening on the top is provided for a control rod. After reviewing heterogeneous pile theory and shielding theory, the experimental techniques and results are recorded. Primarily by boron-trifluoride detection methods, the depression due to the shield of slow flux in the boundary regions is compared with an unshielded facility.

2. A VERSATILE FLEXIBLE CONTROL ROD FOR SUB-CRITICAL SYSTEMS<sup>1</sup>.Jackson E. Kinzer and A. Robeson; *Virginia Polytechnic Institute*

The problem of installing a control rod in the V.P.I. subcritical nuclear reactor was complicated by the limiting two foot clearance between the top of the reactor and the ceiling in which to insert and operate an eight foot rod. The problem was overcome by cutting the rod in 6 inch sections at an angle of 45° and installing an internal pivoting arm which allowed the sections to break 60° with respect to one another. This allowed the rod to be wrapped on a drum taking the shape of a hexagonal helix when withdrawn from the pile and yet have the effect of a solid straight rod when inserted in the pile. To eliminate lateral movement of the rod in any direction when inserted, a threading cam was used which corrected for both the helix and hexagonal effect simultaneously. Provision was made to change the neutron absorbing material by using a tubular sleeve cut in the same manner as the rod and sandwiching the absorbing material between the rod and sleeve of each section.

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<sup>1</sup>Supported in part by the U. S. Atomic Energy Commission.

### 3. A GRAPHITE SIGMA PILE FOR THE MEASUREMENT OF MODERATOR PARAMETERS.

Lee S. Anthony and A. Robeson; *Virginia Polytechnic Institute*

The Virginia Polytechnic Institute Sigma Pile was constructed of AGOT grade graphite, and is a parallelepiped eight feet high, with a base of 66" x 66". There are foil channels in nineteen layers; the first two foil blocks in each channel are coupled together to facilitate removal. Source positions consist of one central position in level four, and four positions located symmetrically in layer three, at  $\pm a/3$ , where they may be used to minimize harmonics. A framework was placed around the pile, and is used to support positioning plates, which meet the ends of the foil channels on two sides of the pile. A plate consists of  $4\frac{1}{2}$  x  $4\frac{1}{2}$  inch vertically placed channel iron, adopted for easy yet dependable positioning. Horizontal and vertical  $\text{BF}_3$  traverses were obtained to prove the symmetry of the pile. The diffusion length and Fermi Age were run using conventional indium foil techniques. A value of  $54.5 \pm 2$  cm was obtained for the diffusion length, and  $357 \pm 5$  cm<sup>2</sup> for the Fermi Age, indicating that the pile has uniform, acceptable parameters.

### 4. THE VIBRATIONS OF A LOADED CANTILEVER.

I. G. Foster; *Virginia Military Institute*

A solution for the vibratory motions of a simple cantilever, loaded at the free end, is given for the simple case of free vibrations of an undamped bar. Modal frequencies and modal shape functions are derived as functions of the ratio of load mass to cantilever mass. The shape functions are non-orthogonal so that common methods of satisfying initial conditions fail. Since the amplitudes of higher modes are negligible, numerical approximation is possible and the results are in excellent agreement with experiment.

### 5. MEASUREMENTS OF COMPRESSIBILITIES OF SOLIDIFIED GASES AT VARIOUS LOW TEMPERATURES.\*

John W. Stewart and Ralph I. La Rock; *University of Virginia*

The bulk of the work reported here has been with solid methane ( $\text{CH}_4$ ). This substance exhibits two rotational (second order) phase transitions below 32° K and 2,600 kg/cm<sup>2</sup> pressure, and one such transition above this "triple point". These transitions are observed as small discontinuities in compressibility. Measurements have been made to 20,000 kg/cm<sup>2</sup> by the piston displacement technique at a number of temperatures between 4° K and 120° K. The phase transitions noted by

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\*Supported by Office of Ordnance Research, U. S. Army.

Trapeznikova and Miljutin (*Nature* 144: 632. 1939) and by Stevenson (*J. Chem. Phys.* 27: 656. 1957) are substantiated only in part. The compressibility of  $\text{CH}_4$  at atmospheric pressure is  $4 \times 10^{-5} \text{ cm}^2/\text{kg}$  at  $9^\circ \text{K}$ ;  $5 \times 10^{-5}$  at  $30^\circ \text{K}$ ;  $6 \times 10^{-5}$  at  $65^\circ \text{K}$ ; and  $8 \times 10^{-5}$  at  $77^\circ \text{K}$ .

Solid  $\text{CF}_4$  has been investigated in the range  $65^\circ \text{K}$  to  $89^\circ \text{K}$ . Its compressibility at atmospheric pressure and  $84^\circ \text{K}$  is about  $5 \times 10^{-5} \text{ cm}^2/\text{kg}$ . This substance has a pronounced first order transition at atmospheric pressure and  $76.3^\circ \text{K}$  (*Zeit. Physik. Chem.* B41: 307. 1938). At  $88.5^\circ$  the transition pressure is found to be  $1,210 \pm 75 \text{ kg/cm}^2$ .

#### 6. EXPERIMENTAL DETERMINATION OF THE DENSITIES OF SEVERAL SOLIDIFIED GASES AT $77^\circ \text{K}$ .\*

Ralph I. La Rock and John W. Stewart; *University of Virginia*

The densities of solid methane, ethane, ethylene, propane, propylene, and carbon tetrafluoride at  $77^\circ \text{K}$  have been measured at atmospheric pressure by direct condensation of the gas into a volumetric flask immersed in a liquid nitrogen bath. The accompanying pressure drop in a storage tank of known volume at room temperature was observed. The mass of gas in the tank before and after condensation was readily determined in terms of the number of moles,  $n$ , from the equation

$$n = \frac{PV}{RT \left[ 1 + \frac{B(T)}{V} \right]}$$

The second virial coefficient,  $B(T)$ , was obtained from values given in the literature. The results listed below are based upon a minimum of eleven runs with each substance.

Substance	Density $\text{gm/cm}^3$	Molar Volume $\text{cm}^3$
Methane	$0.507 \pm 0.004$	$31.6 \pm 0.2$
Ethane	$0.713 \pm 0.002$	$42.2 \pm 0.1$
Ethylene	$0.732 \pm 0.002$	$38.3 \pm 0.1$
Propane	$0.763 \pm 0.004$	$57.8 \pm 0.3$
Propylene	$0.806 \pm 0.003$	$52.2 \pm 0.2$
Carbon Tetrafluoride	$1.943 \pm 0.007$	$45.3 \pm 0.2$

\*Supported by the Office of Ordnance Research, U. S. Army.

## 7. ROLLING POLYGONS.

Robert C. Yates; *College of William and Mary*

This is a discussion of the geometric problem of rolling a regular polygon of  $N$  sides upon a line and upon the outside and the inside of another regular polygon. By using trigonometric formulas for the sum of sines and the sum of squares of sines, arc lengths and areas were computed in elementary fashion as functions of  $N$ . By letting  $N$  increase without bound, the areas and arc lengths of the *ordinary cycloid*, *hypocycloid*, and *epicycloid* were determined. The audience was provided with sheets of colored drawings containing the essentials of the discussion.

## 8. THE MAGNITUDES, COLORS, AND MOTIONS OF STARS OF THE SPECTRAL CLASS R.

Gordon L. Vandervort; *University of Virginia*

Visual magnitudes and colors of 98 stars of the spectral class R have been observed with a photoelectric photometer and reduced to the system of Johnson and Morgan (*Ap. J.* 117: 313. 1953.) The average probable error of one magnitude amounted to  $\pm 0.^m055$  and that of the color,  $\pm 0.^m039$ . The variation of the color with spectral class is shown in the following table.

Subclass	No. of stars	Ave. Color	p. e. Unit Wt.
R0	19	1.22	$\pm 0.13$
R2	28	1.33	0.13
R5	23	1.57	0.16
R8	7	2.10	0.08
Var.	21	2.46	0.46

Statistical parallaxes were derived by means of the parallactic motion as well as by the use of the tau-components compared with the peculiar components of the radial velocities. After correcting the apparent magnitudes for the interstellar absorption, the average absolute magnitudes were derived for the two groups of stars as shown in the second table.

Group	No. of Stars	$\overline{M}$
R0 and R2	43	$+ 0.44 \pm 0.29$
R5 and R8	42	$- 1.10 \pm 0.49$

## 9. A SEARCH FOR DISTANT BLUE STARS IN HIGH GALACTIC LATITUDES.

Charles R. Cowley; *University of Virginia*

A survey of McCormick 10 inch spectral plates has yielded one hundred-six blue stars in regions within 40 degrees of the north and south galactic poles. Colors, magnitudes, and proper motions were obtained for the 12 stars having negative color indices. Spectroscopic parallaxes indicate that these bluest stars are well above the plane of the galaxy, and are therefore probably Population II stars. Many of the A stars exhibit strengthened G bands, possibly indicating that these stars are also of Population II.

## 10. THE RICHMOND AREA SEMINAR FOR HIGH SCHOOL MATHEMATICS TEACHERS.

E. Sherman Grable; *University of Richmond*

During the past year a monthly seminar has been conducted for high school mathematics teachers in the Richmond area. The programs have been conducted by representative speakers from colleges and universities, business and industry. Interest proved to be high, with an average attendance of approximately fifty teachers. As a result of this interest and enthusiasm a five-week workshop will be held during the coming summer. Financial support has been secured from business and industry. Attendance will be limited to forty teachers each of whom will receive a small stipend. The project has amply demonstrated that there is both interest in and support for efforts to strengthen the mathematics curriculum in our public schools.

## 11. LONG-ENDURING METEOR TRAINS AND FIREBALL ORBITS.

C. P. Olivier; *University of Pennsylvania*

This paper presents data on meteor trains and fireballs in larger amount than, it is believed, has previously appeared. The factors which must be present for train development are discussed and it is shown that the development of a long enduring train is a comparatively rare phenomenon. Mean heights for both trains and fireballs are given, along with the velocities of train drifts. Vector diagrams for drifts of night trains over America and Europe are redrawn, generally confirming those in Reprint 69. The monthly frequency of fireballs and their ratio to other meteors are derived. It is shown that while many have such orbital inclinations that origin in the asteroid zone was possible, others could not have originated there. Results, previously and currently obtained by the older naked-eye methods, are confirmed quite closely by the newer photographic and radio methods, despite the much greater absolute accuracy of the latter.

## 12. AN UNDERGRADUATE LABORATORY COURSE IN NUCLEAR PHYSICS.

F. R. Crownfield, Jr.; *College of William and Mary*

Experiments for an undergraduate laboratory course in nuclear physics are briefly described. The experiments are designed to use standard, up-to-date nuclear physics apparatus to illustrate fundamental nuclear physics principles. The student thus gains a working knowledge of modern apparatus at the same time he does experiments in basic nuclear physics.

## 13. SOME GAMMA RAY EXPERIMENTS FOR AN UNDERGRADUATE COURSE IN NUCLEAR PHYSICS.

E. T. Gerry and F. R. Crownfield, Jr.; *College of William and Mary*

Gamma ray attenuation and Compton effect experiments using a scintillation spectrometer are described. Measurements of "narrow beam" absorption coefficients are made by using energy selection instead of collimation. By omitting the energy selection one finds considerably less attenuation and this demonstrates the concept of buildup factor, often neglected in introductory courses. The energy shift due to Compton scattering may be measured by determining the pulse-height spectrum of a monochromatic (Ca-Ba<sup>137</sup>) source and comparing it to the spectrum of radiation scattered by a lead ring through an angle which can be easily determined geometrically.

## 14. DESIGN AND CONSTRUCTION OF A LONG LENS BETA SPECTROMETER.

J. W. Little and J. F. Roach; *College of William and Mary*

This instrument consists of a long solenoid and a plexiglas vacuum chamber. The electrons are detected by a scintillation phosphor, and the light pulses are transmitted to a photo multiplier tube outside the solenoid by a long light pipe. Electrons up to one MEV can be focused.

## 15. THE QUANTUM THEORETICAL CONCEPT OF MEASUREMENT.

John L. McKnight; *College of William and Mary*

The first section of the paper is devoted to the development of a set of criteria for an adequate interpretation of measurement in quantum mechanics. They are founded on traditional epistemology and metaphysics. An epistemological scheme similar to that of Northrop and Margenau is developed which will fulfill these criteria. On this base it is proposed that variables such as position, momentum and the like are not uniquely possessed by quantum mechanical systems. Between acts of measurement it would contradict quantum theory to ascribe definite values to the classical observables of the system. The observables are latent in this strong sense and appear only during the measuring process.



The characteristic interdependent statistical predictions of the values of those pairs of variables whose operators do not commute result from the process nature of measurement. This interpretation is applied to several examples and used to explain the Bohr principle of complementarity.

16. COMMENTS ON MAGNETIC THIN FILMS.

G. Wayne Clark; *Virginia Institute for Scientific Research*

The results of some recent theories and experiments on magnetic thin films are briefly reviewed. For the experimental results emphasis has been placed on films prepared by evaporation of the metals in vacuum.

17. HYSTERESIS LOOP TRACTOR FOR MAGNETIC THIN FILMS.

Billy W. Sloope; *University of Richmond*

A circuit which has been adapted from that given by Howling (*Rev. Sci. Inst.* 27: 952. 1956) and employing the Rubens (*Rev. Sci. Inst.* 16: 243. 1945) cube coil is described. This apparatus is designed to display the hysteresis loop of extremely thin magnetic films of NiFe. Several uses of the apparatus and loop patterns are mentioned.

18. MAGNETIC DOMAINS BY THE KERR MAGNETO-OPTIC EFFECT

Calvin O. Tiller; *Virginia Institute for Scientific Research*

The Kerr magneto-optic effect has been employed to observe or photograph magnetic domains in thin vacuum-evaporated films of nickel-iron (approximately 80% nickel). A method of obtaining a magnetic hysteresis loop from a photographic trace will be shown.

19. COERCIVE FORCE VS. THICKNESS FOR THIN FILMS OF NICKEL-IRON.

Calvin O. Tiller and G. Wayne Clark; *Virginia Institute for Scientific Research*

An investigation of the behavior of the coercive force as the thickness is decreased for thin vacuum-evaporated films of nickel-iron (81% nickel) is reported. It is found that the inverse  $4/3$  power of thickness dependence as predicted by Neel is not fulfilled.

20. WHAT SHOULD WE DO ABOUT CENTRIFUGAL FORCE AND EARTH SATELLITES?

Billy W. Sloope; *University of Richmond*

The role and use of the term 'centrifugal force' in the explanation of earth satellites as opposed to the usual academic use is discussed. Also the role of the scientists in public science education is touched upon.

## 21. PHARMATOMITY-ATOMS FOR PEACE.

Agnes K. Beall; *Virginia Beach*

*PHARMATOMITY* — a name coined by the author — covers application in the field of *PHARM*acy of *ATOM*ic research for better *commu-NITY* health. It was pointed out that human welfare has already been enhanced by the application of atomic energy developments and by-products through pharmaceutical research in medicines and drugs now available and in use. These products are the foundation of today's highly successful medical therapy but are only the forerunners which reasonable expectancy indicates will be forthcoming from pharmaceutical laboratories.

## 22. MILLIMICROSECOND PULSE AMPLIFIERS.

W. T. Joyner; *Hampden-Sydney College*

A survey of available vacuum tubes shows that the FEP-60 secondary emission pentode offers the best figure of merit for pulse amplification. A negative feedback circuit is necessary to insure stable performance. A univibrator circuit is described which has a sensitivity of two hundredths of one volt and an output slope of  $10^{10}$  volts/sec. Recent solid state amplifiers are shown to be considerably better than available vacuum tubes, particularly at low signal levels.

## 23. A RELAXED CONDITION ON THE EXISTENCE THEOREM FOR SIMULTANEOUS IMPLICIT FUNCTIONS.

Reuben R. McDaniel; *Virginia State College*

Given the system of  $n$  equations

$$f_i(x_1, x_2, \dots, x_n, y_1, y_2, \dots, y_m) = 0 \quad (i = 1, 2, \dots, n)$$

in  $m+n$  unknowns defined at a point

$$P \equiv (x_1^0, x_2^0, \dots, x_n^0, y_1^0, y_2^0, \dots, y_m^0).$$

By the well known Existence Theorem for implicit functions one can find a value

$$x_k^0 = f_i(y_1^0, y_2^0, \dots, y_m^0)$$

provided (1)  $f_i$  and its  $n$  partial derivatives  $f_{ix_k}$  ( $k = 1, 2, \dots, n$ )

exist and are continuous in the neighborhood of  $P$  and (2) the Jacobian,  $J \neq 0$  at point  $P$ . In this paper we show that, if  $f_i$  ( $i = 1, 2, \dots, n$ ) are

homogenous functions in  $x_1, x_2, \dots, x_n$ , and if  $x_k \neq 0$  for some value  $k$ , the condition that  $J$  be different from zero may be replaced by the statement:

$$\begin{bmatrix} f_{1x_1} & f_{1x_2} & \dots & f_{1x_{k-1}} & f_1 & f_{1x_{k+1}} & \dots & f_{1x_n} \\ f_{2x_1} & f_{2x_2} & \dots & f_{2x_{k-1}} & f_2 & f_{2x_{k+1}} & \dots & f_{2x_n} \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ f_{nx_1} & f_{nx_2} & \dots & f_{nx_{k-1}} & f_n & f_{nx_{k+1}} & \dots & f_{nx_n} \end{bmatrix} \neq 0$$

This may be verified by simply replacing  $\frac{\partial f_1}{\partial x_k}$  by its value found from a statement of Euler's Theorem for homogenous functions.

24. A FURTHER STUDY ON NEWTON'S INTERFERENCE PATTERN FROM COATED SURFACES.

H. Y. Loh; *Virginia Polytechnic Institute*

Newton's interference patterns produced by combination of simple geometrical surfaces such as circular cone, ellipsoid of revolution, etc., were discussed previously (V. J. S. 3:4). A further study has been made on patterns from cylindrical surface in combination with others. Their characteristics have been found and verified experimentally. Micrographs of the interference patterns from surfaces coated with highly reflective film are shown.

25. ON THE MECHANICAL PROPERTIES OF WHISKERS OF HEXAGONAL METALS.

P. B. Price, M. J. Skove, and N. Cabrera; *University of Virginia*

The mechanical properties of zinc, cadmium, and copper single-crystal whiskers were studied with a micro-tensile device constructed for this purpose. It was found that these whiskers were quite strong and had sharp yield points. Second order effects in the stress-strain curves were noticed at high stresses. These second-order effects varied from crystal to crystal, indicating that the crystals were not perfect but rather had dislocations present. To study these dislocations creep experiments were done and the results indicate that Frank-Read sources are still active in whiskers with a cross-section of the order of  $5 \times 10^{-8} \text{ cm}^2$ . The high yield point stresses are presumably due to the small size of the crystal preventing pile-ups of dislocations from breaking through the oxide layer on the nearly perfect surface.

## 26. THE EFFECT OF HIGH STRAIN AND LOW TEMPERATURE ON THE RESISTIVITY OF METAL WHISKERS.

Herman H. Hobbs and E. P. Stillwell, Jr.; *University of Virginia*

A thorough study has been made of the effect of elastic strain on the resistivity of copper whiskers. Preliminary results on whiskers of several other metals have also been obtained. The effect of plastic flow on the resistance has also been studied. The strain-resistivity curves in the elastic region are found to depart from linearity for all metals studied.

The residual resistance of whiskers of several metals has been measured. The residual resistance of reduction grown copper whiskers is found to be between ten and twenty percent of their resistance at zero degrees Centigrade. Cadmium and zinc whiskers grown by condensation of their metal vapor in inert gas have been shown to have residual resistances of about one percent of their resistances at zero degrees Centigrade.

## 27. PHOTODISINTEGRATION OF LIGHT NUCLEI.

P. Flournoy, R. Tickle, and W. Whitehead; *University of Virginia*

A series of experiments has been started at the University of Virginia to investigate the photodisintegration of light nuclei. This paper is a report on preliminary data obtained for the neutron production cross sections of  $\text{He}^4$  and  $\text{N}^{14}$ . The 70 Mev Electron Synchrotron was used as a source of gamma-rays. Fast neutrons from photonuclear reactions induced in gaseous targets are thermalized in kerosene and detected by boron-trifluoride counters. The neutron pulses were amplified and fed into a coincidence circuit along with a  $800\mu$  Sec gate. The gate was triggered  $35\mu$  Sec after the beam pulse so that no pulses were recorded during the gamma-ray burst. Yield curves were obtained by recording neutron counts as a function of the maximum photon energy from threshold to 50 Mev. A thin-walled, parallel plate ionization chamber was used to monitor the gamma-ray flux. This monitor was calibrated relative to the  $\text{Cu}^{63}(\gamma, n)\text{Cu}^{62}$  cross section as measured by Berman and Brown. Cross sections for  $\text{He}^4$  and  $\text{N}^{14}$  were extracted from the yield curves using the Penfold-Leiss matrix.<sup>1</sup> Parameters of the "giant resonance" peaks are:

	$E_p$	$\partial p$	$\Gamma \frac{1}{2}$	$\int_0 \sigma^{50}(E)dE$
$\text{He}^4$	23.7 Mev	1.3 mb	8.0 Mev	.011 Mev-Barns
$\text{N}^{14}$	22 Mev	9.7 mb	4.6 Mev	.088 Mev-Barns

where  $E_p$  = energy of peak

$\partial p$  = value of cross section at peak

$\Gamma 1/2$  = width of resonance at half maximum

$\int_0^{\infty} \sigma^{50}(E) dE$  — integrated cross section to 50 Mev.

## 28. THE $Al^{27}(\gamma, 2P)Na^{25}$ REACTION

L. B. Aull and W. D. Whitehead; *University of Virginia*

An electron synchrotron was recently given to the University of Virginia by the General Electric Company. The maximum energy of the X-ray beam is variable from 10 to 70 million electron volts, and a maximum beam intensity of approximately 300 roentgens per minute is obtained at one meter from the tungsten target.

The synchrotron has been used to investigate the  $Al^{27}(\gamma, 2P)Na^{25}$  reaction. The  $Na^{25}$  activity induced in an aluminum sample and the  $Cu^{62}$  activity induced in a copper sample after a short irradiation were measured with a scintillation counter at various beam energies between 23 and 65 Mev. The cross section for the  $Al^{27}(\gamma, 2P)$  reaction was then computed from the above data, the known  $Cu^{63}(\gamma, n)Cu^{62}$  cross section, and the theoretical X-ray spectrum. Peak cross section is at 32 Mev., the half width for the cross section curve is about 8 Mev, and the integrated cross section is 2.7 mb — mev.

## BUSINESS MEETING

The Astronomy, Mathematics, Physics Section business meeting was held at 11:40 AM, Friday, May 9, 1958 in the Cavalier Room, Hotel Roanoke. The following officers were elected by unanimous vote of the members: *Chairman*, Jackson J. Taylor; *Secretary*, Robert C. Yates; *Section Editor* (1960), I. G. Foster. The Chairman appointed Miss Isabel Boggs representative to the VAS Committee on the History of Science in Virginia.

Jackson J. Taylor, *Secretary*

## SECTION OF BACTERIOLOGY

## BUSINESS MEETING.

1. SERUM BACTERICIDIN LEVELS FOR *Bacillus subtilis* IN HUMAN MALIGNANCIES.

H. C. Alexander and Eva Soto-Figueroa; *Department of Microbiology, University of Virginia School of Medicine*

Previous studies have shown that pneumococcal pneumonia and myocardial infarction produce an increase in the serum levels of bactericidin. Data from further studies revealing that increase in concentration is also seen in patients with carcinoma of the lung and Hodgkins disease are presented in this report. Bactericidin levels are expressed in units per ml. of serum.

Bactericidin titers found in 8 cases of primary epidermoid carcinoma in the lung ranged from 3 cases with levels of 2 to 4 units, within the normal range of healthy humans, to one case with 32 units. The diagnoses in all cases in this study were made on the basis of biopsy and histological characteristics. Only one case was resectable. The remaining patients showed evidence of extensive metastasis to mediastinal structures and pleura. Only one case showed evidence of associated infection.

Four patients with anaplastic carcinoma of the lung had bactericidin levels of 64 units. Of these patients one was resectable and the others evidenced signs of metastasis to hilar and mediastinal structures, and to axillary nodes and adjacent tissues. No patients showed active infection.

Five patients with Hodgkins disease showed titers of 16 to 64 units with no correlation between duration of disease and titers since histories ranged from 3 months to 15 years. All patients represented acute exacerbations of their disease with mediastinal involvement in all but one, while none demonstrated lung parenchymal disease or active infection. Patients with adenocarcinoma of the lung had 16 units. Patients with multiple myeloma, breast carcinoma, lymphatic leukemia, and pernicious anemia were within normal limits.

In summary, bactericidin levels are increased in epidermoid and anaplastic carcinoma of the lung and Hodgkins disease. In contrast, studies by Southam and Pillemer on properdin levels in patients with malignancies indicate depletion. Collectively these findings illustrate two distinct host responses involving antibacterial systems.

2. RAPID DETECTION OF *Salmonella typhosa* BY FLUORESCENT ANTIBODY TECHNIQUE.<sup>1</sup>

Walter R. Dowdle, Charles T. Hall and P. Arne Hansen; *Department of Microbiology, University of Maryland*

The importance of multiple labeling by fluorescent antibodies for the simultaneous demonstration of several antigens in one preparation has been emphasized. Immune typhoid globulin labeled with fluorescein and adsorbed with antigens 9 and 12, leaving Vi and d antibodies only, acts as a double label since the two fluorescent antibodies stain two different morphological structures. Hence this adsorbed serum makes it possible to differentiate *Salmonella typhosa*, which has both Vi and d, from all other *Salmonellae*.

3. STUDIES OF HUMAN TISSUE ANTIGENS.

Gerald Goldstein and Quentin N. Myrvik; *Department of Microbiology, University of Virginia School of Medicine*

4. A SEROLOGICAL AND PHYSIOLOGICAL STUDY OF HETEROFERMENTATIVE LACTOBACILLI.

Anne Zerschling and P. Arne Hansen; *Department of Microbiology, University of Maryland*

The characterization of a group of common major antigens of the heterofermentative lactobacilli would afford a valuable adjunct to the present physiological classification since the lines of demarcation among the species have proved to be somewhat vague. With respect to the agglutination-agglutinin adsorption technique, however, the 49 strains analyzed exhibited a distinct tendency toward strain specificity, particularly among the strains classified physiologically as *L. brevis*, *L. buchneri*, and *L. cellobiosus*. Strains of *L. fermenti* of fowl origin also exhibited marked strain specificity, but six *L. fermenti* strains from a variety of other sources shared a common antigenic complex. It was possible to distinguish these strains from all others by either of two antisera appropriately adsorbed.

5. LYSIS OF MODIFIED ERYTHROCYTES BY NORMAL SERUM.

H. J. Welshimer and Nancy G. Winglewish; *Department of Microbiology, Medical College of Virginia*

Sheep erythrocytes have been treated with polysaccharide extracts of *Listeria monocytogenes*, *Staphylococcus albus*, *Salmonella typhosa* and *Bacillus megaterium*. Such treated erythrocytes will undergo lysis in the

<sup>1</sup>This work was performed under contract with the U. S. Army Chemical Corps, Fort Detrick, Frederick, Md.

presence of normal guinea pig serum, human serum and rabbit serum. The C'3 component of complement combines with the polysaccharide. The lytic activity of the serum is related to the complement activity. Antibodies against the polysaccharides have not been detected in the normal serum and are not believed to be involved in this lytic phenomenon.

6. METHODS OF REVEALING INGESTED BACTERIA IN *Entamoeba histolytica*.

E. Clifford Nelson; *Department of Microbiology, Medical College of Virginia*

The thickness and optical properties of the ectoplasmic layer of *E. histolytica* interferes with observation of ingested bacteria with the ordinary light microscope and even with the phase microscope. The present study was made to attempt to devise more adequate techniques for observing ingested bacteria. A vital staining, crystal violet procedure has given good results in revealing bacteria in living amebae. A combined Wright-Giemsa staining procedure has given best results for killed and fixed permanent preparations.

7. A MICROBIOLOGICAL STUDY OF ANTARCTIC BIRDS.

John McNeill Sieburth; *Animal Pathology Section, Virginia Polytechnic Institute*

Five studies conducted during earlier antarctic expeditions indicated that as many as fifty per cent of the antarctic birds were "bacteriologically sterile". This study was conducted aboard the icebreaker "General San Martin" during the 1957-58 Argentine Antarctic Expedition. Four of eighteen birds were free of aerobes and in the scope of the earlier workers would also be considered as "bacteriologically sterile". However, these birds had an obligate-anaerobic microflora.

Antibacterial assays, direct microscopic observations and bacterial counts on gastrointestinal material indicated marked antibacterial activity in the proventriculus contents of penguins eating Euphausian Shrimp. The antibiotic activity of the shrimp was located in its phytoplankton laden stomach. Sea water phytoplankton *per se* was active at concentrations as low as five parts per million dry weight. Similar studies indicated that the antibacterial activity of proventriculus contents from birds pre-dating on penguins was due to the marked antibacterial activity of blood serums.

Penguins were free of a detectable tracheal microflora while the flying birds had both a tracheitis and a tracheal flora of enterobacteria pathogenic for chickens. Serological tests indicated that Salmonellosis and Ornithosis occur in antarctic birds.



## SECTION OF BIOLOGY

## 1. COMPATABILITY RELATIONSHIPS IN THE CONVULVULACEAE.

Robert J. Knight; *Blandy Experimental Farm, University of Virginia*

Compatibilities have been studied of twenty-four species from six genera. Fifteen of the species were in the genus *Ipomoea*. Self-compatible taxa included the following 15 species. *Calonyction aculeatum*, *C. muricatum*; *Quamoclit coccinea*, *Q. lobata*, *Q. pennata*; *Ipomoea fistulosa*, *I. hederacea*, *I. lacunosa*, *I. lindheimeri*, *I. Nil*, *I. purpurea*, *I. setosa*, *I. trichocarpa*, *I. tricolor*, *I. triloba*. There are nine species which were found to be self-incompatible. These were *Ipomoea cairica*, *I. cathartica*, *I. pandurata*, *I. tyrianthina*, *I. sp.* (collected at E. Papayo, Mexico); *Jacquemontia martii*; *Merremia tuberosa*, *Convolvulus arvensis*, and *Calystegia sepium*. Data involve the results from (1) interspecific crosses; (2) self- and cross-pollination studies; and (3) the reaction of pollen on stigmas or in styles following self- or cross-pollinations.

It is considered that there have been parallel trends within several genera toward loss of self-incompatibility reactions, and that development of the annual habit of growth is closely associated with a high degree of self-compatibility in the Convolvulaceae.

## 2. PRELIMINARY STUDIES OF CAVERNICOLOUS FUNGI.

William W. Scott and Margaret M. Holland; *Virginia Polytechnic Institute*

Although the fauna of caves has been intensively studied by many investigators, little attention has been given to the plant life present in such habitats. The obvious reason for this discrepancy is the dependency of green plants upon light. However, it might be expected that the fungi would thrive in such an environment. Preliminary studies support the anticipated presence of an abundant population of soil and water inhabiting fungi within a number of caves in southwestern Virginia.

The present investigation has been concerned primarily with troglomorphic phycomycetous fungi. A large number of isolates representing about 25 chytridiaceous, saprolegniaceous, and pythiaceus species have been studied and identified.

## 3. SAGA OF VIRGINIA'S WATER LILY (AMERICAN LOTUS).

Agnes K. Beall; *Virginia Beach*

While found in the eastern states from the Canadian border to Louisiana, the yellow American Lotus exists in profusion today only in the Princess Anne County area of Virginia. This plant flourishes best in

fresh, still waters and is water hardy. Hurricanes and high tides in coastal areas, bringing salt water, can wipe out a colony because of salt action on roots and tubers. The potentialities and significance of current research on *Nelumbo lutea* were stressed and methods of cultivation for home gardens (previously considered impractical) were described. Care must be exercised to avoid tender plant tips being damaged or the whole plant dies. The chemical and biological characteristics, historical significance and striking beauty of American Lotus are deserving of far greater attention than previously accorded this native heritage.

4. A COMPARATIVE STUDY OF THE PHALLIC PAPILLA OF FOUR GENERA OF CRAYFISHES OF THE FAMILY ASTACIDAE.

Thomas L. Johnson; *University of Virginia*

The distal portion of the sperm duct, lying in the phallic papilla of the coxal podomere of the fifth pereopod of the crayfish, bears a cuticular lining. The shape of this cuticular element suggests that it is instrumental in molding the spermatophore so as to facilitate its passage along the groove of the first pleopod, the organ of sperm transfer in the crayfishes of the northern hemisphere. A comparison of this cuticular structure in the distal portion of the sperm ducts in representatives of four genera of the Family Astacidae is made with the intention of determining whether or not modifications of it are of phylogenetic significance.

5. PRECOLONIAL GAME CONDITIONS IN VIRGINIA.

John H. Reeves, Jr.; *Virginia Cooperative Wildlife Reserve Unit, Virginia Polytechnic Institute*

Studies were made regarding the conditions of forests and fields in Virginia before 1600. With knowledge of the habitat, combined with early reports concerning the abundance of game animals, the following inferences seem logical: (1) The forests of this period were composed of mature or over-mature hardwood trees. Pines were scattered, being found only on the immediate coast or in tracts near the mouths of large rivers. (2) While forests covered most of Virginia, there was considerable open land. These clearings were both agricultural and non-agricultural in purpose, and as much as 1,200 square miles of open land existed in precolonial Virginia. In the untilled savannas grasses grew in abundance. (3) Mast producing trees and grasses of savannas served, respectively, game species as bear and turkey, and grazing forms as elk and bison. The large herds of deer were restricted to edges of forests since the preferred shrubby plant growth was largely lacking in forests. Farm game animals, rabbits and quail were present, but in limited numbers. (4) Much of the open land in Virginia was a direct result of indiscriminate burning of the woods by the Indians. The thought has been ex-

pressed that if this burning had been continued by the Indian, eventually, he would have destroyed or radically changed most of the forests of Virginia.

6. HOST SPECIFICITY AND *Odostomia impressa*, SAY.

J. Frances Allen; *University of Maryland*

A review of the literature indicates that, in general, members of the Pyramidellidae are considered as being host specific and ectoparasitic gastropods. Personal observations have suggested that such is not the case. A study of several species of this family relative to their feeding habits has been initiated, and *Odostomia impressa* Say, because of its accessibility, was selected for the first concentrated observations. Although previously reported as feeding on *Crassostrea virginica*, *O. impressa* not only utilizes that organism but in addition feeds readily on each of the following: *Bittium varium*; *Crepidula convexa*; *Urosalpinx cinerea*; *Triphora nigrocincta*; a polychaete worm; another species of pyramidellid; and at the incurrent siphon of the tunicate, *Molgula*. Obviously this species is not host specific. As to whether or not it should be considered as an ectoparasite is a matter of definition and interpretation of the term.

7. GENERAL CONSIDERATIONS IN LABORATORY ANIMAL CARE.

Berton F. Hill; *Bureau of Laboratory Animal Resources, National Academy of Sciences*

This paper presents in a brief discussion the general considerations which must be taken into account in the breeding and maintenance of research animals. Several factors which hinder experimental results are noted. Problems in the design and construction of laboratory animal quarters are discussed. Proper equipment for animal colonies and the operational procedures used in such colonies are described. An attempt is made to list and outline briefly several systems of mating, including inbreeding and random mating. Certain rules for the storage and use of animal feed and bedding are given, with particular emphasis on the need for feed free of estrogenic contamination. The spread of infection in a laboratory animal colony and some general methods of control are discussed. Demonstration is made of the hazards encountered in the transportation of laboratory animals and the measures needed to minimize shipping stress. Finally, the attributes of an effective animal caretaker are noted.

8. SALINITY AND OXY-HEMOGLOBIN AFFINITY.

Jack D. Burke; *University of Richmond*

The Hall Spectro-Comparator was used to determine the per cent sat-

uration of human hemoglobin at different oxygen tensions in millimeters of mercury. The hemoglobin was made-up in Sorensen's phosphate buffer at different molarities, and at pH 6.8. Oxygen dissociation curves were determined at each molarity using the Brown and Hill thermodynamical nomogram. The salinity range of eleven determinations was from M/1000 to M/1. When molarity was plotted vs.  $T_{1/2}$  saturation, it was demonstrated that valid oxygen dissociation curves can be determined for human hemoglobin solution buffered in salt concentrations ranging from M/75 to M/10.

9. THE EFFECT OF ULTRA-VIOLET AND X-RADIATION ON THE GROWTH OF *Phleum pratense* ROOTS.

Robert T. Brumfield; *Longwood College*

The growth of timothy roots exposed to UV (8 ergs/mm<sup>2</sup>/sec) for 8 minutes is immediately, but temporarily (3 hr. after irradiation) depressed. The growth of cells in the region of elongation is inhibited while the growth of cells near the tip is slightly stimulated for a short period after irradiation. Exposure to 1600 r of X-rays has no effect on elongating cells but the growth of cells near the tip at the time of irradiation is depressed when they reach the region of elongation. Both types of irradiation differentially affect division and growth of the meristemataic cells. Division is inhibited while growth continues resulting in abnormally long cells.

10. CYTOLOGICAL STUDIES IN *Setcreasea purpurea* BOOM AND *S. brevifolia* (TORR.) ROSE .

Smritimoy Bose; *The Blandy Experimental Farm, University of Virginia*

A  $2n$  number of 12 is found in *S. purpurea* while our *S. brevifolia* plants showed a  $2n$  number of 25. Three different types of chromosomes occur in karyotypes of both species. These are chromosomes with (1) median, and (2) submedian constrictions — both types without any satellites — and (3) submedianly constricted types which have a satellite on the shorter arm. The meiotic behavior of the  $2n=12$  species of *S. purpurea* is normal in all the stages of I and II division. In metaphase I there is a regular formation of 6 bivalents and in microspore division 6 chromosomes are always observed. The cytological behavior shows it to be a diploid.

The meiotic behaviour of  $2n=25$  species of *S. brevifolia* is found to be irregular and univalents, bivalents, trivalents and quadrivalents are generally observed in metaphase of meiosis. Chromatin bridge formations are common at anaphase I and II and large numbers of micronuclei are seen. In microspore division, cells with 11, 12, 13, 14 and 25 chromo-

somes are noticed of which 12 and 13 are in a majority. The evidence suggests it to be an aneuploid with a  $4n + 1$  constitution. Structural hybridity is also believed to be playing a part here.

11. SELECTION OF THE LARGE MILKWEED BUG FOR RESISTANCE TO INSECTICIDES.

James McDonald Grayson; *Virginia Polytechnic Institute*

The large milkweed bug, *Oncopeltus fasciatus* (Dall.) has been subjected under laboratory conditions to selection for survival to sublethal dosages of DDT, toxaphene, and aldrin. No distinct resistance to aldrin or toxaphene had developed after 23 and 37 generations, respectively, but definite resistance to DDT had developed after 36 generations of selection. In addition, the number of eggs produced by DDT-selected females was significantly lower than that produced by normal females, but there was no significant difference between numbers of eggs produced by normal and either toxaphene- or aldrin-selected females.

12. INFLUENCE OF THE SEASON ON THE ANATOMY OF THE SKIN AND FOLLICLES OF WOOLED SHEEP AND DAIRY GOATS.

Lubow A. Margolena; *Agricultural Research Service, U. S. D. A.*

Studies were carried out on the histology of skin and hair follicles of the dorsum of two groups of animals from samples collected throughout the year. One group was kept on pasture, the other under a controlled dietary regime, but otherwise under identical conditions. The 14 animals used included 2 Merino and 2 Hampshire sheep of either sex, 2 female Toggenburg goats and 1 Merino lamb for each group. No variations were observed because of pregnancy, lactation or sex differences, breed being of primary importance.

Measurements and studies were made of the epidermis as the sole progenitor of hair follicles in prenatal stages and in case of skin wounds. Observations were also made of follicles in different stages and of melanocytic distribution.

Provided nutrition is adequate, season is of prime importance in follicular behavior in shedding animals like Toggenburg goats.

The less differentiated and thinner the epidermis, the denser are the follicles and the higher the follicular and skin metabolism as indicated in Beltsville sheep having continuously growing wool.

Melanocytic activity in goats is manifested during the initiation of new hair. Variation in the presence and location of pigment carrying cells, in different breeds, is discussed.

## 13. SHORT-TERM SURVIVAL IN PEN-REARED QUAIL.

Thomas H. Ripley and Russell A. Cookingham; *Virginia Polytechnic Institute and Massachusetts Division of Fisheries and Game*

The characteristics of short-term survival and its relationship to harvest using pen-reared quail were investigated. Three methods of study were used: (1) release and direct counts taken before the open season using birds tagged with plastic markers, (2) analysis of open season band returns from birds stocked during three periods before shooting, and (3) an analysis of the distribution of open season returns from releases made immediately before shooting.

Direct counts of surviving birds from a 261-bird release showed losses of 38, 58 and 66% in 5, 15 and 30 days, respectively. The total return of 184 birds from three stocking periods made at 3, 13 and 28 days before shooting had a distributed contribution of 71, 17 and 12 per cent, respectively. A total return of 101 quail stocked three days before shooting was distributed so that 65, 24 and 11% were taken during the first, second and third, and fourth and fifth weeks, respectively.

A direct relationship between survival and harvest was clearly indicated. The implications of the findings with respect to stocking programs were discussed.

14. INFRASPECIFIC VARIATION IN THE WHITE PERCH, *Roccus americanus* (Gmelin).

William S. Woolcott; *University of Richmond*

The white perch is a euryhaline species which occurs in the bays and coastal rivers of Eastern North America from Nova Scotia to South Carolina. The present population study, an examination of the variation pattern of the species, was made to determine whether various populations differed and, if so, on what level.

Counts of fin rays and scales and measurements of various body parts were made on over 1400 specimens. The data are presented in the form of frequency distribution tables.

In *americanus* there appear to be two primary gene pools located north and south of the Delaware River. Evidence for this was found in anal ray and lateral-line scale counts which were higher in the north. With few exceptions proportional measurements (expressed as percentage of standard length) were greater in the south. The Delaware River population is intermediate in many characters and apparently draws from both northern and southern gene pools. Partially isolated populations within the two major gene pools have diverged on a low level. Some differences are probably the result of selective adaptation while others may

be due to a phenotypic response to environmental influence. In lake populations the specimens were more elongate than were those from rivers.

15. THE APPLICATION OF MARINE BIOLOGY AND OCEANOGRAPHY TO IMPORTANT FISHERY PROBLEMS.

Howard H. Eckles; Chief, *Branch of Marine Fisheries, U. S. Department of Interior*

The fishing industry is faced with many problems which causes economic instability and hardship to its members. These range from depleted stocks and vagaries in fishing conditions to severe competition from imports. While application of marine biology and oceanography cannot solve all the fisherman's problems, science can uncover new resources, stabilize the supply and increase fishing efficiency. Using combined studies of marine biology, oceanography and fishing explorations, new stocks of yellowfin tuna have been found in the equatorial Pacific south and east of Hawaii. Relations between water temperatures and tuna catches show that better catches result when surface layer waters are warmer than average. Low salinity indicates better skipjack tuna catches in the Hawaiian fishery.

Through studies of meristic characters, scales, incidence of parasites, and serology fishery scientists can usually separate red salmon of Asiatic and North American origin caught on the high seas.

Long term investigations usually are necessary to obtain sufficient knowledge to determine effects of environment on abundance of marine fishes. The unusually warm season of 1957 in the Pacific, with sea temperatures 3° to 6° F. higher than average, had a marked effect on important ocean fish populations.

16. THE EXOSKELETON OF A FRESHWATER CRAB AS A MICROHABITAT FOR SEVERAL INVERTEBRATES.

Horton H. Hobbs, Jr. and Alejandro Villalobos; *University of Virginia and University of Mexico*

In the Arroyo Tapalapan, Santiago Tuxtla, Veracruz, Mexico, a freshwater crab, *Pseudothelphusa lamellifrons* Rathbun, was found to be infested with four, supposedly epizootic, animals. One of these, a flatworm belonging to the suborder Temnocephala, represents the second report of a temnocephalid from Mexico, and, to our knowledge, the first definite locality and host record in the Country. The presence of an oligochaete of the family Branchiobdellidae and of an ostracod of the genus *Entocythere* on this crab establishes a new host and a new locality record for both groups; representatives of neither of these groups has been reported

previously from hosts other than crayfishes. A copepod of the suborder Harpacticoida was also present in numbers such as to suggest that the association is not an accidental one.

#### 17. NATIVE SHRUBS OF VIRGINIA.

Arthur L. Eiser; *Virginia Polytechnic Institute*

During the past two years work has been done on the taxonomy, ecology and economics of the native shrubs of Virginia. Some 386 species are known to occur in Virginia; 294 are native deciduous shrubs, 42 are native evergreen shrubs and 50 are naturalized deciduous shrubs. These 386 species are distributed among 115 different genera.

Reports have been assembled as to the uses in wildlife and ornamental fields. More than 120 of the 386 shrubs have been recognized as being of ornamental value. Through field observation and food habit studies more than 128 shrubs have been listed as being utilized by birds and mammals. A few shrubs are used for both food (fruit and browse) and cover thus one cannot subdivide these plants accurately.

#### 18. GRASSES IN VIRGINIA.

A. B. Massey; *Virginia Polytechnic Institute*

The grass family is well represented in Virginia by 408 different kinds distributed among 85 genera; 65 of which are native. It is surprising to note that many of our grasses have been introduced from the old world, mostly Europe. The grasses are of basic importance in our economy. Several species are cyanogenic under certain conditions; hence, are poisonous. Many people are allergic to pollen of certain grasses. Grasses are freely utilized by many species of wildlife for food, cover, nesting and bedding. The writer is making a study of the grasses of the state and will identify specimens showing good leaf and seed head development.

#### 19. STUDIES ON EVOLUTIONARY DIVERGENCE OF THE FLORA OF SOUTHEAST ASIA AND THE SOUTHEASTERN UNITED STATES.

Mary Jo Parrish; *Mary Washington College*, and *The Blandy Experimental Farm*

Genera having a disjunct distribution between Asia and America are compared as to the frequency of intrageneric polyploidy and aneuploidy among species of the two areas, in an attempt to measure the relative cytological stability of these relics of the Tertiary flora.

Although several genera differ as to the presence of polyploid species in Asia and America, a tendency to share this characteristic is apparent. Asian species as a group show a greater variability of chromosome num-



ber, both in the frequency of polyploid series and in the presence of aneuploidy. Aneuploidy is uncommon in the group, being known to occur in approximately 12 per cent of these genera; polyploid species are known for less than one-third of the genera. The cytological stability of these genera may be ascribed to centripetal selection under constant environmental conditions.

20. BLOOD OXYGEN CAPACITY IN FROGS.

F. B. Leftwich; *University of Richmond*

The blood oxygen capacity of 145 frogs, including 50 *Rana pipiens*, 43 *Rana clamitans*, and 52 *Rana catesbeiana* was determined by the Grant modification of the Roughton-Scholander microgasometric syringe method. Mean blood oxygen capacities of 10.3, 6.0, and 6.9 volumes % were found for *R. pipiens*, *R. clamitans*, and *R. catesbeiana*, respectively. Statistically, significant differences existed between the mean blood oxygen capacity values of each species. Blood oxygen capacity per gram of body weight decreased as body weight increased. Consequently, total blood oxygen capacity increased as body weight increased.

21. A PRELIMINARY SURVEY OF THE CILIATED PROTOZOA FROM TREE-BORNE MOSSES AND LICHENS IN THE MOUNTAIN LAKE AREA.

Jesse C. Thompson, Jr.; *Hollins College*

22. CHROMOSOME SEQUENCE CHANGE AND AN INVERSION BRIDGE IN *Rhoeo discolor*.

Raymond O. Flagg; *The Blandy Experimental Farm, University of Virginia*

A different chromosome sequence was described in diakinesis and metaphase I of *Rhoeo discolor*. Perhaps it originated through structural change in a plant with a chromosome sequence like that described by Sax. A gamete containing an opposite complex which had undergone a segmental interchange between non-corresponding arms with non-homologous distal segments, viz. between arm C of chromosome cC and arm b of chromosome bB. The segmental interchange may have been due to a reciprocal translocation or a crossover between homologous differential regions. Many similar rearrangements of chromosome sequence may occur in *Rhoeo* but be undetected or undetectable.

Evidence was presented for a very small, nearly terminal inversion being located in arm d of either chromosome ed or dF. It appears that the distal pairing segments are sufficiently long for chiasmata to form in a region proximal to the inversion, *i. e.*, that the distal pairing segments may be longer than they have been previously considered.

(This study was made from a slide kindly provided by Professor L. Husted.)

## MINUTES OF THE SECTION MEETINGS

## SECTION OF CHEMISTRY

## 1. NEUTRON DIFFRACTION OBSERVATIONS ON THE PALLADIUM-HYDROGEN AND PALLADIUM-DEUTERIUM SYSTEMS.

J. E. Worsham, Jr., M. K. Wilkinson and C. G. Shull; *University of Richmond, Oak Ridge National Laboratory, Massachusetts Institute of Technology*

Neutron diffraction investigations on powdered samples have determined that both hydrogen and deuterium atoms in beta phase Pd-H and Pd-D are located in the octahedral positions of the palladium lattice. Results obtained on samples with low gas concentrations were inconclusive.

## 2. AGGREGATION STUDIES OF SOYBEAN PROTEIN

Carl J. Likes; *Virginia Institute for Scientific Research*

Ultracentrifugal studies on soybean protein extracts have indicated that the degree of aggregation is influenced both by pH and inorganic salts. Experimentally, commercial soybean meal was extracted with 0.2 M NaCl, titrated to a given pH, mechanically dialyzed against 0.4 M NaCl of the same pH as that of the titrated solution and then examined in the ultracentrifuge. At the extraction pH (6.3) and in solutions of pH 8 and 10, the ultracentrifugal pattern consists of three components having sedimentation constants of 1.5, 7.2 and 11 S (Svedberg units). At pH 11, the most rapidly sedimenting component disappears and at pH 12, the pattern, when examined under conditions comparable to those of the previous experiments, shows only a single component of 2.7 S. On prolonged sedimentation, this peak splits indistinctly into two components of 3.1 and 1.3 S. When the pH 12 solution is back titrated to pH 12 and dialyzed, etc., the pattern tends to revert to that found initially for the pH 8 solution.

Repetition of the procedure, but in the absence of salt (removed from the 0.2 M NaCl extract by dialysis), revealed only a single component of 1.57 S at pH 12. Direct addition of NaCl to a 0.4 M level increased the sedimentation constant to 2.3 S. When back titrated to pH 8 and dialyzed against pH 8 distilled water, the salt-free pH 12 solution exhibited no distinctive aggregation tendency, the sedimentation constant being 1.58 S. A 0.2 M saline extract of the meal, subsequently dialyzed against pH 8 distilled water, was found to contain three components of 1.5, 6.0 and 10.0 S.

Results of a generally similar nature were obtained on a commercial soybean protein sample.

3. THE USE OF LOW VOLTAGE MASS SPECTROSCOPY IN QUALITATIVE ANALYSIS OF ORGANIC COMPOUNDS.

Charles Varsel, Francis A. Morrell, Frank E. Resnick; *Philip Morris, Inc.*, and W. Allan Powell; *University of Richmond*

The application of mass spectroscopy to qualitative identifications of organic compounds is limited in some instances because of spectrum complexity, especially in the case of mixtures.

The ionization processes, which occur when molecules are bombarded with electrons, are related to the energy of the bombarding electrons. Normally, a mass spectrum is produced by electrons of 50 to 70 electron-volt potentials. If the energy of these electrons is reduced to some low potential, only molecular ionization will occur. The usually complex mass spectrum is reduced to a single peak, which is that of the molecular ion. The lowest potential necessary for ionization of a molecule to occur is termed the ionization potential.

A Consolidated Electrodynamics Corporation Mass Spectrometer was modified to permit variation of the ionizing voltage over a range of 0-20 volts. This modification permitted the analysis of mixtures at low ionizing voltages, because all organic compounds ionize in the range of 8 to 14 volts.

Low ionizing voltages simplify the mass spectra of mixtures by eliminating peaks caused by fragmentation of molecules. Consequently, qualitative data can be more easily obtained from these spectra than from those produced by high ionizing voltage procedures.

This low voltage technique was described and its application to the identification of unknowns in multicomponent mixtures, containing many compound types, was discussed.

4. THE USE OF INFRA-RED SPECTROPHOTOMETRY IN THE ANALYSIS OF PIPERAZINE SALTS.

William R. Maynard, Jr.; *Virginia Department of Agriculture*

Piperazine salts, the currently preferred drug therapy for oxyuriasis, has proven an interesting problem for analysis. The problem is complicated by the fact that, while the piperazine base and its salts are soluble in aqueous solution, they are insoluble in organic extractive solvents. A more accurate method of analysis, based upon the formation of the diacetyl derivative in 100% yields ( $\pm 1.0\%$ ), was developed. This derivative is easily extracted from an aqueous solution with chloroform.

The method consists of neutralizing the salt with excess sodium bicarbonate, treating the free piperazine base with acetic anhydride in sodium bicarbonate solution and extracting the diacetyl piperazine.

The method is very accurate, whether completed gravimetrically or by infra-red absorption procedures. The accuracy in both cases is within  $\pm 1.0\%$ . The infra-red procedure is preferred because of saving in time that is possible.

A standard of diacetyl piperazine is prepared when using the infra-red method, and the absorbance of this standard is compared to the absorbance of the sample at 10.03 microns. The amount of diacetyl piperazine thus obtained is then converted to its original salt equivalent.

5. A RAPID SPECTROPHOTOMETRIC DETERMINATION OF TOTAL ALKALOIDS IN TOBACCO SMOKE.

Charlotte M. Haynes and Sylvester W. Pleasants; *Philip Morris, Inc.*

The total alkaloids in collected smoke can be separated quickly by steam distillation and can be identified by spectrophotometric examination in the ultraviolet region. The smoke from cigarettes is collected under standard conditions. A suitable aliquot of this solution is made basic, steam distilled and the resulting enriched distillate is examined spectrophotometrically. The method can be very rapidly carried out by employing multiple and automatic steam distillation equipment and by using a continuous flow spectrophotometer cell within a recording spectrophotometer. The method has been shown to be precise and reproducible for the determination of total steam distillable nicotine-type alkaloids in tobacco smoke.

6. SPECTROCHEMICAL DETERMINATION OF CERTAIN TRACE ELEMENTS IN HUMAN PLASMA AND RED CELLS.

Leonel M. Paixao and John H. Yoe; *University of Virginia*

Improvements were made during the previous twelve months, in the procedure for the determination of the trace amounts of magnesium, chromium, nickel, copper and zinc in human plasma and red cells. The improvements were discussed from the standpoint of contamination hazards, reproducibility of results and accuracy.

7. SPECTROPHOTOMETRIC DETERMINATION OF CHROMIUM IN HUMAN PLASMA AND RED CELLS.

Dwight O. Miller; *University of Virginia*

The spectrophotometric determination of chromium is based on a red-violet complex formed by the addition of diphenylcarbazone to a dilute acid solution of dichromate ions. A method for the rapid oxidation of

chromic ions to dichromate was presented. Ferric ions, which interfere with the diphenylcarbazine — dichromate reaction, can be removed by precipitation from dilute hydrochloric acid solution with cupferron, followed by extraction of the precipitate with chloroform.

8. SOME DERIVATIVES OF DITHIOOXAMIDE AS REACTIONS FOR THE SIMULTANEOUS SPECTROPHOTOMETRIC DETERMINATION OF TRACES OF COBALT, NICKEL AND COPPER.

William D. Jacobs; *University of Virginia*

Absorbance versus wave length curves and pH studies of the complexes of cobalt, nickel and copper with eight derivatives of dithiooxamide (rubeanic acid) have been made. One of these derivatives, N, N'-bis (3-dimethylaminopropyl) dithiooxamide, was investigated in detail. Factors affecting the stability of the cobalt, nickel and copper complexes of this compound, such as pH, the use of a protective colloid, temperature and order of addition of reagents were studied. Mole ratios of the three metallo-organic complexes were determined. The adherence of the three color systems to Beer's Law, the effect of foreign ions and the optimum conditions for the analytical use of the reagent were investigated and discussed.

9. SPECTROPHOTOMETRIC DETERMINATION OF ALUMINUM WITH QUINIZARIN-3,3-DISULFONIC ACID NA-SALT.

E. Guy Owens II and John H. Yoe; *University of Virginia*

A method for the spectrophotometric determination of aluminum with quinizarin-2,3-disulfonic acid Na-salt has been developed. Aluminum forms a stable, violet complex with this reagent in methanol solution. The reaction is selective and has a practical sensitivity of one part of aluminum in fifty million parts of solution. The method has been successfully applied to the analysis of a limited number of bronze and steel samples in the range 0.02% to 6.0% aluminum. Preliminary separation of interfering ions was effected with the mercury cathode.

10. SPECTROPHOTOMETRIC DETERMINATION OF URANIUM WITH 3-(2-ARSONOPHENYLAZO)-4,5-DIHYDROXY-B,G-NAPHTHALENEDISULFONIC ACID (TRISODIUM SALT).

H. Perry Holcomb and John H. Yoe; *University of Virginia*

A method for the spectrophotometric determination of uranium has been developed using the trisodium salt of 3-(2-arsonophenylazo)-4,5-dihydroxy-2,7-naphthalenedisulfonic acid. This reagent instantaneously forms a stable purplish-blue complex, which has a maximum absorbance at 590 millimicrons. The mole ratio of reagent to uranyl ion is two to one. The color reaction conforms to Beer's Law and has a sensitivity of one

part in twenty million. Tolerances to diverse ions, effect of temperature and the separation of uranium from interfering ions by ether extraction of uranyl nitrate were investigated. Comparisons between this method and the dibenzoylmethane method were also made.

11. REACTION OF ETHYLENE OXIDE WITH HISTIDINE, METHIONINE AND NICOTINIC ACID.

H. G. Windmueller and C. J. Ackerman; *Virginia Polytechnic Institute*

The deleterious effect of ethylene oxide fumigation on the nutritive value of animal diets prompted a study of the reactions of the fumigant with various nutrients in aqueous solution at room temperature. Histidine reacts rapidly to yield a strongly basic product. Using imidazole in a model system and isolating the product as the HCl salt, the product was identified as 1,3-bis(2-hydroxyethyl)-imidazolium chloride. There is good evidence that in ethylene oxide treatment of histidine the analogous reaction occurs, as well as alkylation of the amino group.

Nicotinamide, when treated similarly, yields as an initial product N-(2-hydroxyethyl)-3-carboxamidopyridinium chloride. The betaine of N-(2-hydroxyethyl)-nicotinic acid was isolated from a solution of nicotinic acid and ethylene oxide at pH 7. All of the above ethylene oxide products are labile to alkali. Ethanolamine can be identified among the degradation products of each.

N-acetylmethionine reacts readily with ethylene oxide to yield a salt containing a strongly acidic and a strongly basic group. It can be precipitated from aqueous solution as the phosphotungstate or the reineckate, and it is believed to be the thetin of S-(2-hydroxy-ethyl)-N-acetylmethionine.

12. IMIDE AND HYDRAZIDE PLANT HORMONES.

Lowell V. Heisey; *Bridgewater College*

A series of imides and hydrazides of alkyl, chloro and hydroxy-substituted maleic and succinic acids were prepared as possible plant hormones. Cyclic and mono- and di-non-cyclic hydrazides, some of which are new compounds, were included in the series.

The purpose of the project is to prepare compounds that might act as metabolic antagonists to the well-known plant hormone, maleic hydrazide, and thus aid in the elucidation of its mechanism of action. Further, it is hoped that compounds with useful physiological actions of their own will be found. The physical properties of the compounds are to be determined and attempts made to see if there is any correlation between certain physical properties and such types of plant-hormone activity as growth stimulation, inhibition or alteration.

## 13. AROMATIC CYCLODEHYDRATION ON SOLID SURFACES.

Frank A. Vingiello and Martin Spangler; *Virginia Polytechnic Institute*

The cyclodehydration of certain aromatic ketones by heating them with aluminum oxide under reduced pressure has prompted a further study of this method of cyclodehydration. Several different solid surfaces have been studied. Preliminary results indicate a correlation between the acid strength of the surface, as measured by adsorbed Hammett indicators, and surface activity. It is hoped that this method can be used to effect cyclodehydration without the concomitant hydrolysis of such groups as methoxy and cyano that usually occurs in homogeneous solution.

## 14. PREPARATION OF SOME CYCLE SULFONES FROM 1,3-PENTADIENE.

Robert C. Krug and James A. Rigney; *Virginia Polytechnic Institute*

In the presence of an excess of sulfur dioxide 1,3-pentadiene reacts to give the cyclic sulfone, 2-methyl-2,5-dihydrothiophene 1,1-dioxide (I) and polymeric substances. Physical constants and the infrared spectrum of I were presented. In the presence of aqueous sodium hydroxide, I is converted to a compound identified as 2-methyl-4,5-dihydrothiophene 1,1-dioxide (II). Sulfone II appears to be identical with the compound obtained from the oxidation of a 2-methyldihydrothiophene and tentatively identified as II by Birch and McAllen [*J. Chem. Soc.*, 3411 (1951)] and with the compound obtained by the cyclization of 5-mercapto-2-pentanone followed by oxidation, reported by Bacchetti and Fiecchi [*Gazz. chim. ital.*, 83, 1037 (1953)]. Bromine adducts from I and II were prepared and two bromine adducts from I were isolated. It is suggested that these latter adducts constitute two racemic mixtures.

## 15. PHYSICAL PROPERTIES OF SYSTEMS OF TOLUENE AND WATER CONTAINING GLYCOL ETHERS.

Newton C. Landis and N. F. Murphy; *Virginia Polytechnic Institute*

The viscosity, densities, surface and interfacial tension and the diffusivity of two phase systems consisting of the dimethyl ethers of ethylene glycol, diethylene glycol, triethylene glycol and tetra ethylene glycol in toluene and water have been measured and compared. The ternary diagrams for the distribution of these ethers between toluene and water show that the systems contain decreased amounts of solutrope as the molecular weights of the ether decrease until the solutrope disappears in the system containing dimethyl ether of ethylene glycol. However, it reappears in the system containing acetone. The physical properties of the systems were compared to show the variation of the physical properties with the molecular weight for the homologous series of solutes.

16. KINETICS OF THE ACID CATALYZED CYCLIZATION OF o-BENZYLBENZOPHENONE IN ACETIC ACID — WATER MIXTURES.

L. K. Brice, Jr., and R. D. Katstra; *Virginia Polytechnic Institute*

Cyclization of aromatic aldehydes and ketones to poly-nuclear hydrocarbons can be effected by a number of acid catalysts, both homogeneous and heterogeneous. A widely used reaction medium consists of a mixture of 48% hydrobromic acid, water and glacial acetic acid. A kinetic study of a typical cyclization reaction in this medium with varying amounts of water, acetic acid and hydrobromic acid was made.

The reactions were carried out in sealed tubes at 100° C., the initial ketone concentration being 0.00500 M in all kinetic runs. The mole % of water in the acetic acid — water solvent was varied between 0 and 44% and the hydrobromic acid concentration between 1 M and 1.7 M. The results indicated that: (1) The cyclization reaction is first order with respect to the ketone concentration; (2) The first order rate constants increase more rapidly than the first power of the hydrobromic acid concentration; (3) The rate of cyclization is extremely sensitive to the concentration of water in the reaction medium, particularly for mole fractions of water less than 0.2.

17. THE ACID CATALYZED DEPOLYMERIZATION OF TRIOXANE IN CONCENTRATED HYDROCHLORIC ACID SOLUTIONS: SALT EFFECTS AND CORRELATION WITH  $H_o$ .

L. K. Brice, Jr., and L. P. Lindsay; *Virginia Polytechnic Institute*

The rates of depolymerization of trioxane to formaldehyde in concentrated hydrochloric acid solutions with and without added salt were measured dilatometrically at 40° C. and 50° C. The trioxane concentrations in all kinetic runs were 0.25 M, the acid concentrations being varied between 2 M and 7 M. The effects of salts ( $LiCl$ ,  $NaCl$ ,  $KCl$ ,  $NH_4Cl$ ,  $(CH_3)_4NCl$  and  $C_5H_5NHCl$ ) on the depolymerization rate were studied.

The results indicate that: (1) The rate of depolymerization correlates accurately with Hammett acidity function,  $H_o$ , at 40° C. and at 50° C. (2) The logarithm of the first order rate constant is a linear function of the acid concentration and the salt concentration, the slope depending upon the nature of the salt. (3) The magnitude of the salt effect on the rate of depolymerization depends upon the radius of the cation of the salt.

18. THE HEAT OF SUBLIMATION OF BORON AND THE GASEOUS SPECIES OF THE BORON-BORIC OXIDE SYSTEM.

Alan W. Searcy and Clifford E. Myers; *Lynchburg College*

The sublimation pressure of boron was measured in three kinds of



crucibles. The heat of sublimation at  $298^{\circ}$  K. was calculated to be  $139 \pm 4$  kcal. The vapor pressure of boric oxide was measured. A heat of sublimation at  $0^{\circ}$  K. of 88.7 kcal. with an average deviation of 0.4 kcal. was calculated. This value is in good agreement with previous values in the literature. The reaction between boron and magnesium oxide was studied in a Knudsen effusion cell at about  $1400^{\circ}$  K. The data led to a calculated stability of  $B_2O_2$  gas, which is in substantial agreement with that measured by Chupka, Porter and Inghram.

19. SURFACE REARRANGEMENTS PRODUCED ON A COPPER MONOCRYSTAL BY THE CATALYTIC REACTION OF HYDROGEN AND OXYGEN.

Richard Y. Meelheim; *University of Virginia*

Surfaces of copper monocrystals, which were used to catalyze the reaction  $H_2 + O_2$  to form  $H_2O$ , were examined with the aid of an electron microscope. These surfaces were roughened during the reaction by the rearrangement of the metal atoms in the surface. This roughening of the surface produced specific facets, powder and thin leaflets. The configuration and perfection of these facets were observed to depend on crystal face and the experimental conditions, which included temperature, oxygen concentration, total flow rate of the gas mixture and time.

With a given set of conditions, the facet configurations on a particular crystal face were reproducible. Crystallographic planes of (111) orientation were the only specific crystal planes formed on these facets. The oxygen concentration (other variables constant) determined the amount of area parallel to each (111) plane formed on a facet and determined which of the (111) faces formed on the facets. All edges were in (110) directions. When all variables were constant except time, the facets grew in size, at a rapidly diminishing rate, while their shapes remained relatively constant.

The thin leaflets grew only from edges of (111) planes. Most of these films contained holes with three or six fold symmetry. Generally, the edges of these holes were straight lines in (110) directions of the parent crystal.

20. CORROSION INHIBITION AND ACTIVATION OF IRON AND OTHER METALS BY METALLIC CATIONS IN FRUIT AND MINERAL ACIDS.

Roger Buck; *Virginia Institute for Scientific Research*

A broad survey was made of the corrosion of aluminum, cadmium, copper, gold, iron, magnesium, manganese, molybdenum, nickel, silver, tin, titanium, tungsten, zinc and zirconium by fruit and mineral acids at the boiling point in the presence of low concentrations of foreign metallic ions. As a general rule, cations of the elements in groups II through V

in the periodic table showed the highest tendencies to decrease the rate of corrosion, and the transition elements in group VIII showed the highest tendencies to increase the rate of corrosion. The relative effects of the ions were functions of the metal undergoing corrosion and the acid used. As far as could be determined, all the metallic ions which affected the corrosion rate did so by virtue of plating out on the metal surface. However, the adherence of the depositing metal did not appear to be related to the effect of the depositing metal on the corrosion rate. The activators and inhibitors altered the corrosion rate at concentrations as low as  $10^{-7}$  to  $10^{-5}$  M. These concentrations are equivalent to 0.1 to 10 atomic layers of the added metal if it is assumed that all the ions end up on the metal surface.

21. AN UNUSUAL ELBS-TYPE REACTION OBSERVED DURING A STUDY OF THE CYCLIZATION OF KETONES.

Frank A. Vingiello, Alexej Borkoved and Walter Zajac, Jr.; *Virginia Polytechnic Institute*

Using previously described methods, the syntheses of three new ketimine hydrochlorides, six new ketones and six new hydrocarbons were accomplished. It was observed that certain ketones undergo both an Elbs-type reaction and a Bradsher aromatic cyclodehydration reaction under the same experimental conditions.

22. AN ELECTRON MICROSCOPE STUDY OF THE OXIDATION OF COPPER SINGLE CRYSTALS IN AQUEOUS SALT SOLUTIONS.

G. Tyler Miller, Jr., and Kenneth R. Lawless; *University of Virginia*

In order to obtain a better understanding of the reactions of metals in aqueous solutions, known metal single crystal surfaces were immersed in a salt solution and after removal were examined by means of the electron microscope.

On immersion of copper single crystals into  $\text{CuSO}_4$  solution, it was found that well-shaped individual polyhedra of  $\text{Cu}_2\text{O}$  were rapidly formed on the metal surface. The orientation, geometric form, and number of these polyhedra varied with crystal face. The orientation relationships between the oxide and metal were the same as those observed for the oxidation of copper in pure water at  $25^\circ\text{C}$ . and in air at higher temperatures. The geometric form varied with crystal face so as to expose the optimum number of (111), (100) and (110) faces of oxide. Growth spirals usually appeared on the (111) faces of the larger oxide polyhedra and, in addition, etch pits were observed to form adjacent to the oxide polyhedra. Finally, it was shown that annealing the specimen in hydrogen prior to oxidation in solution favored the formation of the

individual oxide polyhedra.

These results were discussed in terms of existing ideas of dry oxidation and in terms of the electrochemical theory of corrosion.

#### BUSINESS SESSION

A short business session of the Chemistry Section was held at 5:00 P.M. on May 9. The selection of a contributor for the proposed publication on the history of science in Virginia, to be sponsored by the Academy, was discussed. This was referred to the incoming chairman for his selection of a committee to work out the matter. The report of the nominating committee was presented, and the following officers were elected for the 1958-1959 period by unanimous vote of the members present:

*Chairman* — Frank V. Vingiello

*Secretary* — Mearl A. Kise

#### SECTION OF EDUCATION

##### 1. THE CONSERVATION KNOWLEDGE OF VIRGINIA SCHOOL PUPILS.

Robert H. Giles, Jr.; *Virginia Commission of Game and Inland Fisheries*

The Virginia Cooperative Wildlife Research Unit conducted a study to determine the conservation knowledge of Virginia's public school pupils in grade 6 through 12. Cooperating in the project were the Virginia State Department of Education, Virginia Commission of Game and Inland Fisheries, Virginia Polytechnic Institute, Wildlife Management Institute and U. S. Fish and Wildlife Service. Data obtained from testing 15,443 pupils in 61 statistically sampled schools throughout the State showed that (1) an adequate management instrument had been developed for testing pupils' knowledge of the principles of wise resource use, (2) pupils thought they knew more about conservation than they did, (3) suburban pupils had greater conservation knowledge than town, large city, or rural pupils, (4) farm boys and girls obtained lower scores than pupils of other home environments, (5) Caucasian pupils had significantly more conservation knowledge than did Negro pupils, (6) Virginia pupils' knowledge of conservation was deficient, (7) significant recommendations based on the results of the evaluation were possible.

##### 2. SOME CHARACTERISTICS OF YOUTH ENROLLED IN AN INSTITUTION OF THE HARD OF HEARING.

Alonzo M. Myster; *Virginia State College*

The purpose of this investigation was to determine whether or not stu-

dents in certain hearing loss classifications differed with respect to ratings on personality traits. The group investigated included 122 pupils enrolled in a school for the deaf; distributed among three hearing loss categories: slight, moderate and severe. For purposes of determining whether or not hearing loss was independent of personality rating, the chi square test of independence was utilized. The results of the investigation indicated that in general hearing losses were not associated, in a fiducial sense (using the five per cent level of significance), to personality ratings. It is believed that these results may be attributed to limitations inherent in the study: (1) the instrument is probably lacking in validity and reliability and (2) there were small frequencies in one or more cells of the contingency table. Investigation of these considerations is under way.

3. VALIDATION OF THE WERT-MYSTER FARMING ATTITUDE SCALE IN A GROUP OF HIGH SCHOOL PUPILS IN VIRGINIA.

Alonzo M. Myster; *Virginia State College*

The purpose of this investigation was to determine the reliability of the Wert-Myster Farming Attitude Scale in a small group of high school pupils. The subjects utilized were 36 pupils enrolled in the Nansemond County Training School and 83 pupils enrolled in the East Suffolk High School. In addition the regression of attitude on ages was investigated. In general, although the coefficients of reliability were not exceptionally high, they were of sufficient magnitude to indicate that the test is useful for purposes of surveying attitudes of groups. Moreover, the coefficients of reliability were sufficiently high, in some cases, to suggest that they should be useful for purposes of individual diagnosis. Comparisons of coefficients of correlation obtained in the groups studied yielded higher estimates of reliability for the vocational scale than for the life scale. In comparing the coefficients of reliability obtained in this study with those obtained in the validating groups significant differences were generally observed. The regression of attitude on age was very low among the Nansemond County Training School Pupils; the proportion of the variance in attitude scores associated with age was approximately 16 per cent. Among the East Suffolk pupils the sum of squares due to the regression of attitude on ages was not significantly greater than zero, in a fiducial sense. Curvilinear regression was not significant; the mean square for deviations from curved regression was larger than the mean square for curvilinearity of regression.

4. DEVELOPMENT OF THE INTERESTS IN ELEMENTARY SCHOOL AS STUDIED BY A PICTORIAL INTEREST SCHEDULE.

Shelva Dove and George W. Kent; *Bridgewater College*

A nonverbal pictorial interest scale utilizing the psychophysical method

of paired comparison was administered to 220 elementary school children ranging from the first to the eighth grade in Rockingham County, Virginia. This scale employed nine line drawing pictures representing nine interest areas found from teacher ratings to be common among elementary children. Statistically significant sex differences were observed on all but two of the interest categories. There was a small negative correlation between the rank ordering of interests for boys and for girls. Boys tended to excel girls in outdoor, sports, and mechanical interests, while girls tended to excel boys in social, artistic, reading, and musical interests. A statistically significant difference was found between first and eighth graders on all nine interest categories, thus indicating real changes in interest with age. The trends of interest change for boys and girls were similar for seven of the nine categories as shown by moderate to high rank order correlations. A small negative correlation was observed between boys and girls on mechanical interests with boys tending to increase their scores while girls decreased theirs.

While the statistical sample employed in this study permits neither a generalization about the nature and development of interests in elementary school, nor about the various possible factors which affect them, the data from this study are taken to indicate that a nonverbal pictorial interest scale may be a useful tool. It may be used to discover major interests of the moment and for investigations of the nature and change of children's interests.

#### J. A WORD COLOR ASSOCIATION TEST.

Harry S. Beck; *University of Virginia*

This test proposes to measure or evaluate an individual's attitudes toward such things as: home, family, school, authority, work, interpersonal relationships, etc. It is also suggested that it may be useful in differentiating diagnostic groups such as: delinquents, neurotics, etc. The rationale is that color has affective value for the individual and that this value remains constant at least for the duration of the test. By having the subject associate given stimulus words (60) with given colors (11) the stimulus words can be associated with each other since the color acts as a common denominator. For example, the color black may be associated with father, authority, hate, teacher, boss, and unhappy. This would suggest that the subject dislikes those in authority over him, etc.

Evidence was presented showing that with 800 Junior High School subjects certain colors tend to be associated with certain stimulus words at very significant levels of confidence (.001). Also that color choices remain stable over a period of one week. The test can be administered either individually or to groups.

## 6. THE APPLICATION OF OPERATIONS RESEARCH TO EDUCATIONAL PROBLEMS.

John M. Long; *University of Virginia*

In this paper the investigator has attempted to describe some of the results found in an exploratory study of operations research. The purpose of the study was to seek out new research tools for accomplishing educational research. It was found that operations research, although generally classified as applied research, is really neither pure nor applied research. It is rather a third type of research which attempts to analyze operating systems as a whole and at the operating level. It is correctly classified as research since its basic purpose is understanding. Operations research draws on a broad area of knowledge and uses scientific methods. Perhaps operations research draws heaviest from mathematics and the physical sciences. There are, of course, some concepts which seem more typically part of operations research than of any other area. Two of these concepts, the Queuing Theory and Optimization or Sub-optimization, were discussed briefly and in a non-technical manner. A number of applications of these concepts to educational problems were suggested. The applications might be classified into two groups.

First, there were a number of applications which were more or less direct and practical in nature. Most of these were quite similar to those successfully made in business and industry.

Second, there were suggestions for some rather abstract applications in the realm of educational theory. In this sense, the proposal is for the development of mathematical structure for educational theory — one that would be relatively free of philosophical controversy.

## 7. THE HUMAN GOVERNOR: CYBERNETICS AND COMMUNICATIONS THEORY.

David D. Redfield; *University of Virginia*

Cybernetics and communication theory formulate an interesting basis on which to develop concepts and ideas pertaining to Behavioral Science, Psychology, and Education. Authorities have hypothesized that "society can only be understood through a study of the messages and communication facilities which belong to it." Pattern and organization are found inherent in such messages and it is possible to interpret the information carried by a message as essentially the negative of its entropy, and the negative logarithm of its probability. The total human capacity of information acceptance is treated as limited by interfering variables in performing a task.

1. Structure of an organism is an index of performance expected from it. Responses are determined by utilization of information fed to the

organism and utilization of this information is a measure of efficiency.

2. When voice is interpreted as being invalid information or limiting human capacity, entropy is increased and performance is limited.

3. Effective behavior appears to be limited through some sort of feedback process and lends the human organism to be considered mathematically as a servomechanism or closed-loop automatic control system.

Finally, the human organism is considered using a systems approach to performance reliability, where communication system effectiveness is treated in generalized form.

## SECTION OF ENGINEERING

### 1. AERODYNAMIC CHARACTERISTICS OF A HEMISPHERE IN NEWTONIAN FLOW.

E. Brian Pritchard; *Virginia Polytechnic Institute*

It has been the purpose of the present investigation to determine the lift and drag coefficients for a hemisphere in Newtonian flow at any angle of attack. The hemisphere lift and drag coefficients have been determined for the limitations of pure Newtonian flow. Also, by consideration of the centrifugal forces resulting from the curved paths of the air particles an improvement on the Newtonian corpuscular theory has been obtained for the determination of the hemisphere lift and drag. In the present paper, expressions for the lift and drag coefficients are derived for both Newtonian flow and Newtonian-plus-centrifugal flow. These expressions are presented and compared in the form of plots of  $C$  and  $C$  versus angle of attack.

### 2. CHARACTERISTICS OF COMPLETE MISSILE CONFIGURATIONS IN HYPERSONIC FLOW.

Robert W. Truitt and William Grossmann, Jr.; *Virginia Polytechnic Institute*

The theory of wing and body characteristics in subsonic, transonic, supersonic and hypersonic flow is well established. Nevertheless, an accurate aerodynamic analysis of a simple wing and body combination is not easy to accomplish in the subsonic, transonic and supersonic flow regimes, and even more difficult is an analysis of a complete aircraft configuration due to complex wing-body interaction forces.

It is assumed that no such complexity of interaction forces exist in the hypersonic flow regime, based on concepts of simple Newtonian impact theory. A component method for analyzing hypersonic configuration is presented which enables the aerodynamic and stability characteristics of aircraft in hypersonic flight to be determined quite easily. Several typical hypersonic missile configurations were analyzed and compared with use of the component method.

The component method of aerodynamic analysis derives its value due to the fact that it is a simple method to apply. It is anticipated that the component method will assume a major role in the determination of aerodynamic characteristics of space craft re-entering the earth's atmosphere at very high speeds.

### 3. MINIMUM DRAG CONFIGURATION FOR HYPERSONIC FLOW.

Robert W. Truitt and Thomas H. Thornton, Jr.; *Virginia Polytechnic Institute*

Minimum drag planforms having been found for subsonic and supersonic flight, this paper derives the minimum drag planform for a swept wing in hypersonic continuum flow and illustrates a method by which the drag may be calculated. Considering the flow from a continuum viewpoint only, Newton's Impact Theory along with a consideration for pressure changes due to centrifugal forces are used to derive the minimum drag planforms. The wings considered have an aspect ratio of  $1/2$  or less and are described by the  $n$ -power equation, that is, flow similarity exists.

The minimum drag planforms are found for a given profile, root chord, and span-thickness ratio or aspect ratio and the corresponding drag coefficients calculated. Also drag coefficients are found for planforms other than minimum drag planforms. When the minimum drag planform is used for the case of a profile normal to the free stream, a fixed span thickness ratio, and a profile thickness one-tenth of the wing span, a reduction in drag of 30% is obtained over a rectangular wing of the same span-thickness ratio.

### 4. LONGITUDINAL STABILITY DERIVATIVES OF MISSILE SHAPED BODIES AT HYPERSONIC SPEEDS,

Robert H. Tolson and James B. Eades, Jr.; *Virginia Polytechnic Institute*

The general equations are developed for the longitudinal stability derivatives of axisymmetric bodies in Newtonian flow. The derivatives are evaluated for four  $n$ -power bodies, including the minimum drag shape. Also presented is a stability analysis for a missile-shaped body with a conical nose, a cylindrical afterbody and a conical tail flare. The



stability effect of nose, afterbody, and tail flare geometry are discussed separately and in combination. The results of the investigation show that statically stable high density, hypersonic missiles will also be dynamically stable.

#### 5. SOME ASPECTS OF MAGNETOHYDRODYNAMICS.

Robert W. Truitt and Richard D. Wagner; *Virginia Polytechnic Institute*

Until recently the study of magnetohydrodynamics has been, for the most part, confined to the fields of the astrophysicist and the geophysicist. However, at the present time the aerodynamist has become involved in the study of magnetohydrodynamics due to the possible advantageous effects obtained by the application of a magnetic field to the flow over a body at hypersonic speeds. The purpose of this paper is to investigate the physical laws governing the interaction of conducting fluids flowing through magnetic fields. An analysis is made deriving the magnetically induced body force on the moving conducting fluid. In addition, the application of a simple physical model shows the retardation effect of the magnetic field on the fluid velocity. With these simple results, it was possible to obtain approximate effects on the sheer stress, drag, and heat transfer rates in the stagnation region of a blunt nose missile at extreme hypersonic speeds. The results show very close agreement with more detailed magnetohydrodynamic analyses.

#### 6. AERONAUTICAL APPLICATIONS OF MAGNETOHYDRODYNAMICS.

Robert W. Truitt and Norris E. Mitchell; *Virginia Polytechnic Institute*

In modern high speed flight, the production of strong shock waves will cause the air to become partially or wholly ionized. It has been found that the flow of an ionized gas is retarded by the presence of a magnetic field. The study of magnetohydrodynamics is accomplished by considering the Maxwell equations in addition to the equations of fluid dynamics. Since the flow is retarded, magnetohydrodynamic principles could be used in the stagnation region of a hypersonic missile to decrease the heat transfer rate. However, the magnetic effect will cause an increase in the shock wave angle and also an increase in drag coefficient. While the decreased heat transfer rate is desirable the increased shock wave angle and drag coefficient could have adverse effects, unless used to aid in deceleration upon re-entry of the missile into the atmosphere. Hence, an attitude of compromise must be used for design in the field of magnetohydrodynamics as in all other fields.

7. THE EFFECT OF HEAT INSULATION ON THE COOLING REQUIREMENTS OF THE INTERNAL STRUCTURE OF HIGH-SPEED VEHICLES.

John Noble Perkins; *Virginia Polytechnic Institute*

A general method for determining the transient skin temperature of bodies during high-speed flight is presented. The governing differential equation is presented for this purpose, giving the fundamental relations between the transient skin temperature and flight history. The method was employed to compute the time history of the skin temperatures for several hypothetical flight plans, and the results presented in the form of graphs

An investigation to determine the effect of heat insulation on the cooling requirements of the internal structure of a high-speed vehicle was made. The governing equation for heat conduction through an isotropic solid was developed, and then modified to account for nonhomogeneous materials. The initial and boundary conditions for the governing equation were specified, and the equation solved by the method of finite-differences. The time history of the inner surface temperature of the insulation was calculated for several thicknesses. To make the solution as general as possible, the results are presented in terms of the thermal diffusivity of the insulating material.

8. JOINING ALUMINUM WITH HIGH ZINC SOLDERS BY ABRASION SOLDERING.

O. R. Singleton, Jr.; *Reynolds Metals Company*

Abrasion soldering of aluminum with high-zinc-content solders is a very useful and, until recently, an unpublicized technique. Above about 700° F zinc solders become molten and alloy readily with aluminum when an aluminum surface is subjected to a slight abrasion action under the molten solder. No flux is required; however, the solder will not flow into or join areas which have not been abraded.

Once acquainted with this soldering technique, an operator can quickly become sufficiently skilled to produce consistently fine joints in small sections of heavy gauge. Either large sections or thin gauge sections require considerable operator skill and experience. Material under about 0.02" thickness is generally not adapted to this joining technique.

High-zinc abrasion-soldered joints will usually have the best corrosion resistance obtainable for soldered aluminum. To attain this corrosion resistance, the solder base stock must be pure zinc (99.99% zinc) from which alloys containing small amounts of aluminum or magnesium may be made. Even small amounts of impurities, especially of lower melt-

ing point metals, have significantly detrimental effects on joint corrosion resistance.

#### 9. HYPERSONIC DRAG REDUCTION BY BLUNTING.

Robert W. Truitt and Claiborne R. Hicks, Jr.; *Virginia Polytechnic Institute*

A theoretical investigation has been conducted in order to obtain a simplified approximation to Newton's minimum drag body for given fineness ratios of unity in the hypersonic speed range. It has been found that Newton's minimum drag body, which is described by two parametric equations which require a laborious procedure to obtain their solution, may be closely approximated by the simple geometry of a blunted cone frustum body, defined by a given fineness ratio. Thus by replacing a given fineness ratio body with the blunted cone frustum body, the pressure drag can be reduced by within one or two % of the minimum drag obtainable and the aerodynamic heating problem is greatly relieved.

#### 10. A CORRELATION FOR DRAG COEFFICIENT AT TRANSONIC SPEEDS-AXIALLY SYMMETRIC FLOW.

James B. Eades, Jr.; *Virginia Polytechnic Institute*

The wave drag for cone-cylinder bodies of revolution in axisymmetric transonic flow is calculated using the Principle of Stationarity of local Mach number. It is found that the method gives good agreement with experiment and theory throughout the transonic range of Mach numbers, and for a wide range of cone apex angles.

These data, in the transonic range, are then correlated using a form of similarity. This similarity condition is not based explicitly on the governing equation of motion, but rather on the physical aspects of the problem. For the correlation a reduced drag coefficient is described which is given as a function of the Mach factor squared.

#### 11. EFFECT OF ANGULARITY IN COMPRESSION TEST SPECIMENS,

B. A. Niemeier and M. F. Rupp; *Reynolds Metals Company*

Lack of perpendicularity of the parallel ends of compression test specimens was studied. The most skewed parallelepiped used in this investigation had an angularity up to three degrees from the right angle. Strain measurements using the Microformer and SR-4 strain gages at selected positions on the test specimen were made in detail. Stress strain curves produced from imperfect specimens are discussed. The critical point value of compressive yield strength of imperfect specimens with angularity up to three degrees is not found to be significantly different from those obtained from the more nearly perpendicular specimens.

12. **HYPersonic SLENDER BODY THEORY IN THE SUPERAERODYNAMIC REGIME.**

R. W. Truitt and C. Howard Robins, Jr.; *Virginia Polytechnic Institute*

A theoretical investigation has been made in an attempt to determine a simple analytical method for determining the minimum drag of slender bodies in rarefied hypersonic flow. The investigation covers three cases of molecular reflection, namely, specular reflection from a smooth surface, specular reflection from a slightly rough surface, and diffuse reflection.

The drag equations determined by Carter for each of these three cases of molecular reflection are simplified by performing a slender body analysis. The resulting equations are then combined with the  $n$ -power body type equation, and closed form solutions for the drag are obtained in terms of fineness ratio and the power  $n$ . These solutions are minimized and the values of  $n$  describing the bodies giving minimum pressure drag under each type of reflection are determined. A check of the results reveals that the analytical method described is valid and gives an excellent approximation to the actual minimum drag bodies.

13. **ARTIFICIAL SATELLITE SPIRAL DESCENT MECHANICS.**

James T. McDaniel and Arthur C. Bruce; *Virginia Polytechnic Institute*

The problem considered in this paper involves the motion of a spherical satellite in a near-circular orbit about the earth with a retarding drag force acting tangent to the path of travel.

The equations of motion are based on a unit mass and are made non-dimensional to make the results as general as possible. The drag term in the governing equations is evaluated with the use of molecular flow theory since the region considered is in the upper atmosphere where the air is not a continuum. Using the resultant drag term in the equations a graphical plot was made and integrated to find the life-time of a satellite in an initially circular orbit at any original altitude from 100 to 1000 miles altitude.

An example problem is presented in the paper which considers a spherical satellite at an initial altitude of 400 miles. Using the results of this paper it was found that the life-time is about two years, four months and ten days.

14. **VEHICLE MECHANICS IN AN EARTH-MOON GRAVITY FIELD.**

John W. Barnes and Arthur C. Bruce; *Virginia Polytechnic Institute*

This paper is concerned with an approximate solution to the trajectory

of a missile initially in orbit about the earth; being supplied with thrust until escape conditions are obtained, and then proceeding on a collision path to the moon.

The problem is readily broken down into three zones, each zone depending on the location of the missile. A closed form solution to the problem (dimensionless in form) was found for the vehicle while in each of the first two zones a simplification was found which reduced the work required to calculate the trajectory of the vehicle while in zone three.

A mathematical investigation was conducted for the problem of orbiting about the moon after the vehicle reached a suitable location. Also the vehicle-mass ratio required to escape the terrestrial attraction was obtained by the use of elementary energy considerations.

15. AN ESCAPE TRAJECTORY FOR A VEHICLE IN THE EARTH-MOON GRAVITY FIELD.

Lester W. Roane and Arthur C. Bruce; *Virginia Polytechnic Institute*

The earth-moon force field was analyzed on a potential basis, and the equations were developed which permit the determination of the magnitude and direction of the total resultant gravity force at any point in the field. A graphical solution allowed the field to be plotted in any plane containing both the earth and the moon. It was found that the moon appreciably disturbs the force field of the earth only in a relatively small area in its immediate vicinity. An analysis of one escape trajectory was carried out considering take-off from the point of neutral gravity between the earth and the moon. The results of this analysis show that escape from this point can be accomplished with thrusts of only about 3 lb/slug under an acceleration of approximately 1/10 g in a very short period of time. It was also shown that for take-off from the region of the neutral gravity point the gravity forces may be neglected with very little error.

**BUSINESS MEETING:** The chairman convened the business meeting at 5 PM on Friday, May 9. The previously appointed nominating committee consisting of Messrs. Niemeier, Truitt and Murphy presented the slate A. C. Bruce for chairman, and O. R. Singleton for secretary. Mr. Bruce declined the nomination because of plans to leave the state at the end of the present academic year. After some discussion the following were elected officers for the coming year:

*Chairman*, B. A. Niemeier

*Secretary*, O. A. Singleton, Jr.

*Editor*, R. M. Hubbard (three year term)

From four contestants of the Junior Academy of Science describing their exhibits, Mr. Malcolm Alden Lillywhite of Washington and Lee High School, Arlington, Virginia, was selected to receive the 1958 George Washington Award of the Engineering Section. The business meeting was then adjourned.

16. DECOLORIZATION OF CAUSTIC WASH LIQUORS FROM CHLORINE-BLEACHED, SULFATE, WOOD PULP.

Peter W. Ruggieri, Jr. and Nelson F. Murphy; *Virginia Polytechnic Institute*

The pH of the highly colored caustic waste (light transmittance of ten % was adjusted by the addition of acid waste from the chlorination stage of the pulp bleaching process. Satisfactory decolorization (light transmittance of 85 %) was obtained by coagulation with aluminum sulfate, available as papermaker's alum slurry.

Commercial flocculating aids, such as Separan 2610, failed to be of appreciable value as a supplement to alum requirements. Other methods of treating the waste, such as initially chlorinating it prior to alum treatment, coagulation with concentrated acids, and coagulation with ferrous sulfate, proved unsatisfactory.

Preliminary and large scale tests using alum showed that a retention time of two hours in a settling tank after mixing produced an effluent with 85 per cent light transmittance and a sludge volume equal to 25 per cent of the total volume. Efficient dewatering of the sludge was obtained by centrifugation. The concentrated sludge from the centrifuge was ashed and 83.5 per cent of the alum recovered by digestion with sulfuric acid.

On the basis of the data collected, a pilot plant was designed and evaluated on the basis of 1,000,000 gallons of caustic waste per day.

17. OVERALL MASS-TRANSFER COEFFICIENTS FOR A HOMOLOGOUS SERIES OF POLY-GLYCOL ETHERS BETWEEN TOLUENE AND WATER.

Nelson F. Murphy and Robert H. Pusey; *Virginia Polytechnic Institute*

This investigation was performed to study the effect of a homologous series of solutes on the overall mass-transfer coefficients for liquid-liquid extraction. Four polyglycol dimethyl ethers were used as solutes. The molecular weight of the solutes varied from 90 to 222. Water was used as the carrier solvent, and toluene was used as the extracting solvent. Preliminary laboratory work was performed to determine the phase diagrams and physical properties—density, viscosity, surface tension, interfacial tension, and diffusivity—for both phases. All measurements were made

at 30°C. A dipping refractometer was used to measure refractive indices for analysis of samples.

Eight countercurrent-flow, extraction tests were performed in a 1½-inch diameter, horizontal, glass tube, eight feet long. The feed concentration varied from 13 to 15 weight % of solute in water. The solvent phase flow rates varied from 19 to 34 pounds per hour, and the water phase flow rates varied from 15 to 35 pounds per hour. The overall mass-transfer coefficients based on both phases were calculated. The coefficients based on the water phase varied from 0.0022 to 0.0133 feet per hour, and the coefficients based on the solvent phase varied from 0.0056 to 0.0237 feet per hour.

18. STUDIES IN ADSORPTION USING MOLECULAR SIEVES.

C. W. Price, P. H. Terry, and F. W. Bull; *Virginia Polytechnic Institute*

Adsorption isotherms were determined for methanol on Linde types 4A and 5A molecular sieves at 66° C, and for n-butanol on type 5A molecular sieves at 120° C. It was found that Freundlich's equation was of greater value in predicting these isotherms than were Langmuir's or the general adsorption equations.

A series of dynamic adsorption tests were performed using alcohols and hydrocarbons as the adsorbate materials. Samples of the effluent from these tests were analyzed by a vapor phase partitioner. The alcohols decomposed in the presence of molecular sieves at 135° C to form ethers, water, and both saturated and unsaturated hydrocarbons. Iso-octane decomposed to form four or more unidentified materials in the presence of molecular sieves at 400° C. Straight-chain hydrocarbons, n-heptane, and n-hexane underwent no changes when contacted with type 5A molecular sieve at 400° C.

The amount of n-butanol decomposed in the presence of type 5A sieve increased from 56.5 weight % of the original material at 138° C to 75.4 weight % at 182° C.

19. A CONTINUOUS COUNTERCURRENT ADSORBER FOR INSTRUCTIONAL PURPOSE.

F. W. Bull, S. A. Burnette, and J. S. Chowning; *Virginia Polytechnic Institute*

The purpose of this investigation was to employ the fluid-solids technique to the design and construction of a continuous countercurrent gas sorption column which could be used with a wide range of systems and for instructional purposes to demonstrate the fluid-solid technique.

Using primarily the equations used for the design of liquid-gas col-

umns, a column of four inches in diameter and containing four plates, spaced at eight-inch intervals, was designed. The column was constructed of pyrex glass pipe sections to facilitate observation of the action on the plates. Solids flow control was accomplished with modified gate valves. The plates were made from grade 2, Porex plate 1/4-inch thick.

Operational tests on the equipment, using the system regenerated catalytic cracking catalyst-air showed that the solids flowed smoothly through the column and at no point was stagnant or bridged solids observed. An increase in pressure drop across the plates with time of operation eventually made the column inoperable. Upon dismantling the column it was found that the Porex plates had been plugged with elutriated fines of an average particle diameter of seven microns. Because of this plugging, grade 2, Porex plate is impractical as a plate material and it is recommended that the Porex plates be replaced with bubble-cap trays.

## 20. EVALUATION OF FACTORS AFFECTING THE EXTRACTION EFFICIENCY OF AN EXPERIMENTAL, LIQUID-LIQUID-PULSE EXTRACTOR.

D. L. Merrill, R. M. McEachem, R. E. Rood, and F. W. Bull; *Virginia Polytechnic Institute*

The evaluation of the effects of pulse amplitudes of one, two, and three inches, solvent-to-feed ratios of 0.5, 0.75, 1.0 1.25, and 1.5 and a feed concentration of ten weight per cent acetone in toluene on the extraction efficiency of an experimental, liquid-liquid, pulse extractor were made using water as the solvent.

The extractor consisted of a 2-inch diameter glass column containing eight perforated plates having 23% plate-free-area. The pulsing mechanism consisted of a brass bellows and push-rod assembly actuated by an eccentric cam. The pulse frequency was 5.3 cycles per minute.

By employing various solvent-to-feed ratios, characteristic curves were obtained for the different pulse amplitudes for steady-state conditions. Blowing of the light phase occurred for volumetric solvent-to-feed ratios less than 1.0 and dumping of the heavy phase occurred for ratios greater than 1.0.

Overall mass transfer coefficients were found to increase with increased pulse amplitudes. Also, the transfer rate increased for the conditions of blowing and dumping; however, much greater for the former condition. Additional data will be obtained for feed concentrations of 5 and 15 weight percent acetone in toluene. Average plate efficiencies and HTU's will also be calculated.



21. TRUE-AVERAGING, NON-SATURATING ELECTRO-PNEUMATIC CONVERTER  
H. R. Blane and W. P. Walker; *University of Virginia*.

The electro-pneumatic converter constructed and described is a rugged, completely transistorized, precision instrument to be used for the conversion of millivolt a.c. signals to pneumatic pressure for control and measurement purposes. Its light weight, compactness, and moderate d.c. power requirements are merits not before offered in this type of device. The unique principle of operation of this instrument enables it to read the true average of rapidly fluctuating signals, and to maintain full sensitivity even under adverse conditions of poor phasing or nulling of the device supplying the input signal. These features are accomplished by using a wide range linear transistor demodulator to detect and average the error signal at a low amplitude (approximately 1 mv). The necessary further amplification is then accomplished by a transistor chopper and amplifier. The entire system is enclosed within a feedback loop to compensate for any non-linearities or drift in either the electrical or pneumatic circuits.

22. RESEARCH ON FOCUSERS FOR MOLECULAR BEAM OSCILLATORS.

K. L. Haynes, R. L. Ramey, and O. R. Harris; *University of Virginia*

A molecular beam oscillator (Maser) consists of three elements: a nozzle which forms a molecular beam; a focuser-separator which uses the Stark Effect to reject the lower energy molecules and focus the upper energy ones; and a microwave cavity which is caused to oscillate by these upper energy state molecules reverting to a lower energy state.

The scope of this paper is confined to a study of focuser-separators for use in ammonia ( $\text{NH}_3$ ) Masers. The ammonia Maser is the only type which has been developed sufficiently to warrant a study of its components; however, much of the theoretical material presented could easily be applied to other molecules.

The basic theory is reviewed and a theoretical expression of the molecular trajectories is developed for a new type of disk focuser. Several computed trajectories are presented. Experimental data showing the effect of focuser potential on the beam distribution is given.

23. EVALUATION OF HIGH TEMPERATURE ANTIOXIDANTS.

Dennis M. Frame and James W. Cole, Jr.; *University of Virginia*

This paper covered the development and evaluation of additives for use in synthetic lubricants, several of which were illustrated. The construction and use of a thermostated furnace for heating these oils under oxidizing conditions was discussed. The system consisted of a sample

cell through which air was passed and which was placed in molten Wood's metal at the test temperature to simulate conditions of use.

The indices or criteria used to determine the degree of oxidation were also discussed and illustrated. The changes in the system which indicated oxidation were mainly those of insoluble formation, acid and peroxide formation, viscosity change, weight losses, and spectrum changes. Mention was also made of recent work using such criteria as conductance. The catalysis of metals, particularly copper, in oil-additive systems was illustrated by the measurement of the effective life of the system versus the presence or absence of metals.

Using the system composed of Plexol 201 as an oil and phenothiazine as an additive, the effects of variations in additive concentration, test temperature, and metal catalysis were given. Data on the relative anti-oxidant power of several phenothiazine derivatives were shown.

#### 24. APPLICATION OF ANALOG COMPUTING EQUIPMENT TO EXTRACTION CALCULATIONS.

Patricio Castro and Otis L. Updike; *University of Virginia*

In a study of the speed and accuracy advantages of analog computation for the diffusional operations, several mechanizations of a stagewise, countercurrent extraction cascade were devised. For a ternary system, the simplest setup required six coefficient "pots", eight computing amplifiers (three as active filters), three diode function generators, and a five-cup servomultiplier. This mechanization, though restricted to steady-state problems, yields data on flow rates and compositions between stages as well as on number of stages. It was tested on a Type I liquid-liquid system in which acetone was extracted from water by trichloroethane. After setup, the number of stages could be calculated twice as fast as by graphical methods, with only slightly lower accuracy. Since setup time is longer, the analog method is superior only when many stages (in one or several cascades) are to be computed for the same system. Principal sources of error were the function generators and a division circuit. Changes in both should result in improved performance. Extension of the technique to other flowsheet configurations, to distillation, absorption, or adsorption, and to transient conditions may be made.

#### 25. MECHANISMS OF THE LOW PRESSURE POLYMERIZATION FOR ETHYLENE TO POLYETHYLENE.

Y. K. Pan and F. C. Vilbrandt; *Virginia Polytechnic Institute*

Ethylene polymerization was carried out in an air-free 200 ml bottle. Solutions of 0.17 to 1.34 gm of  $\text{AlCl}_3$  and 0.1 to 1 gm of  $\text{TiCl}_4$ , dis-

persed or dissolved in 20 ml of xylene, were used as catalysts. Temperatures of 45°, 55°, 115° and 135° C, and maximum pressures of ethylene of 45 to 55 psig were used. The reaction was stopped when the pressure in the bottle dropped to a vacuum, sometimes to 25 inches vacuum.

After adding isopropanol to the reacted solution, a white or brown precipitate formed. A portion of it could be melted on a hot plate from 50° to 100° C. Most of the precipitate was dissolved in water; a few pieces, showing the characteristics of solid polyethylene, floated. During filtration of isopropanol solution, some viscous oil was apparent on the filter paper.

In another series of tests conducted in the presence of 0.046 to 0.006 gm. oxygen similar results were obtained. A pilot plant for ethylene polymerization was described. Information concerning the effects of states of monomers, concentrations of catalysts, temperatures, and pressures on polymerization will be obtained.

26. THE SEPARATION OF A HYDROGEN-CARBON DIOXIDE MIXTURE BY GASEOUS DIFFUSION.

Russell A. Primrose and Frank C. Vilbrandt; *Virginia Polytechnic Institute*

A mixture of 50 mol percent hydrogen and carbon dioxide was diffused through a Dexitlas fiber glass filter 0.008 inches thick manufactured by C. H. Dexter and Sons, Inc. A separation of 2 per cent was obtained at a flow rate of one cubic foot per hour and a vacuum of 20 inches of mercury. Using a 1106-B fiber glass filter 0.018 inches thick, manufactured by Mine Safety Appliances Company, a separation of 3 percent was obtained at a flow rate of 4 cubic feet per hour and a vacuum of 20 inches of mercury.

27. MECHANISMS BY WHICH ULTRASONIC ENERGY AFFECTS TRANSFER RATES IN LIQUID-LIQUID EXTRACTION.

H. A. Woodle, Jr. and Frank C. Vilbrandt; *Virginia Polytechnic Institute*

High frequency sound waves are known to produce numerous and varied effects in a liquid system. This investigation was undertaken to illustrate the effects of subjecting a two-phase, three-component liquid system to ultrasonic waves.

Experimental work was conducted at frequencies of 40 and 800 KC, and at varied times and intensities of treatment. Extraction, in the concentration range of 14.4 to 14.8 weight percent methyl alcohol in toluene by distilled water was studied both with and without ultrasonic treatment.

Results of cocurrent and countercurrent tests show that isonation in-

creases extraction rates by increasing interfacial area between phases through local agitation and mixing at interfaces, by removal of minute stagnant liquid layers at the interfaces through continuous induced agitation and circulation currents, and by a continual supply of fresh material from both phases to the interface through bulk phase circulation currents.

## SECTION OF GEOLOGY

### 1. WHAT IS BASEMENT IN VIRGINIA?

Charles E. Sears; *Virginia Polytechnic Institute*

The problem of determining what is basement is a difficult one and in many cases is mainly one of definition. If basement is defined as consisting of rocks of different sedimentary and or structural environment separated by a profound break which may be due to several causes, we can talk about basement regardless of rock types or ages. Using this definition, there can be more than one basement. Under this definition, basement in Virginia can be described as follows: The first basement would consist of rocks of the Piedmont types which underlie the Coastal Plain sediments and which may also underlie the Paleozoic rocks of the area from the Blue Ridge Alleghany Plateau. The second basement, if present, would consist of rocks older or more complexly folded and metamorphosed than the metasediments-sedimentary-igneous complex of the Piedmont. It is possible to conceive of a third basement which may underlie the second basement rocks. Under this definition, rock types and ages need not be considered.

### 2. STRATIGRAPHIC AND GEOGRAPHIC DISTRIBUTION OF SOME UPPER CLINTON (SILURIAN) BRACHIOPODS.

C. G. Tillman; *Virginia Polytechnic Institute*

An analysis of the stratigraphic distribution of brachiopods within the lower part of the Middle Silurian Series in the eastern United States reveals that brachiopod assemblages can be used successfully for regional correlation. Based on brachiopod distribution, the upper part of the Osgood formation and probably most of the Laurel limestone of Indiana may be correlated with the Irondequoit limestone of New York. The Waldron shale of Indiana correlates with the Rochester shale of New York.

Three parallel, environmentally controlled, faunal zones based on bra-

chiopods can be recognized in rocks of Rochester age from Indiana eastward to the limit of the Silurian outcrop in the central Appalachians. The westernmost environmental zone is characterized by the rich Waldron-Rochester fauna. The two easternmost zones are distinguished by progressively impoverished Waldron-Rochester faunas and by the appearance of several new forms.

Preliminary work suggests that these parallel environmental zones roughly coincide with regional distribution of rock types. The westernmost zone is in a region of limestone and dolomite with minor shale, the next zone eastward is in a region mainly underlain by shale with some limestone, and the easternmost zone is in a region mainly underlain by sandstone with some shale.

### 3. GEOMORPHIC SIGNIFICANCE OF RESIDUAL AND ALLUVIAL DEPOSITS IN THE SHENANDOAH VALLEY, VIRGINIA.

John T. Hack; *United States Geological Survey*

Study and mapping of the surficial deposits in the drainage basin of the Shenandoah River indicate a close relation between bedrock and the distribution of residual and alluvial deposits. Saprolite is widely distributed on the Cambrian and Ordovician limestones, especially on rocks like the upper part of the Beekman town dolomite that contain massive chert. The chert forms a residual mantle of stones that protects the finer grained insoluble residue from erosion. Saprolite is commonly absent on rocks like the Martinsburg and Athens formations that, on weathering, do not yield coarse insoluble fragments.

Alluvial deposits cover less than one-third of the valley floor, and occur where streams enter limestone or shale areas from mountains underlain by more resistant sandstone and quartzite. Coarse alluvium is deposited near the mountain foot by laterally migrating streams in pediment-like aprons. Piracies occur in these areas because the main streams issuing from the mountains have steeper gradients than their own minor tributaries that head on the valley floor, in softer rocks.

The rough accordance of summit levels of the hills on the valley floor that has given rise to the concept of a valley floor peneplain results from the adjustment of slopes to a regularly spaced drainage network in a region having rocks that are roughly of the same resistance. Relief is considerably lower in the Martinsburg shale areas, however, than in limestone areas and is highest in the outcrop belt of the Beekmantown dolomite. The present topography is better explained as the result of long-continued and deep erosion of a folded mountain chain that is close to isostatic equilibrium than by a theory involving still stand, uplift, and erosion, such as the theory of multiple erosion cycles.

4. A FURTHER DISCUSSION OF THE SALTVILLE FAULT IN SMYTH AND WASHINGTON COUNTIES, VIRGINIA.

Wilbur A. Nelson; *University of Virginia*

In 1956 and 1957 additional drilling was carried on about one mile south of the Saltville fault in Washington County, Va. This drill hole which was located on Tin Bridge Road, passed through the Saltville fault at 2401 feet and penetrated the MacCrady formation of Mississippian age. The information obtained from this drill hole supplemented information obtained from several other drill holes completed about ten years ago, extending from near Chatham Hill in Smyth County, Va., and shows for a distance of over twenty miles that the Saltville fault is a low-angle bedding plane fault having an average dip of around  $20^{\circ}$  to the south-east, except along the trace of the fault where steeper dips occur due to the fact that a normal fault occurs just to the northeast of the trace of the Saltville fault, which has downdropped the Saltville fault shingle block and produced a drag along the trace of the fault with dips as much as  $60^{\circ}$ . It is believed that further work along the Saltville fault to the northeast and southwest of this twenty mile section will show that similar conditions exist for some distance along this fault.

5. A PETROGRAPHIC ANALYSIS OF THE MOSHEIM FORMATION AT STRASBURG, VIRGINIA.

W. C. Sherwood; *Virginia Council of Highway Investigation and Research*

The purpose of this paper is to give a petrographic description of the Mosheim Formation as it occurs at the Dominion Quarry, approximately 2 miles NE of Strasburg, Shenandoah County, Virginia. The quarry at this point contains a complete cross section of the formation which strikes N  $45^{\circ}$  E and dips  $30^{\circ}$  to the SE. Nineteen samples were taken at approximately 8 foot intervals over the entire vertical section. Due to the extremely homogeneous nature of the formation, hand specimens show only slight differences. Generally the material is dove gray, compact, very fine grained, thickly bedded, indurated and breaks with a hackley to conchoidal fracture. Frequent inclusions of clear crystalline calcite occur in all but one specimen. Chemical analyses of the Mosheim in this area show  $\text{CaCO}_3$  — 98.25% and  $\text{MgCO}_3$  — .80%. In thin section the rock is shown to be essentially cryptograined calcite. This material shows some degree of transformation to pellets and comprises a total of about 80% of the rock mass. Irregular patches and veinlets of coarse granular calcite roughly parallel the bedding. Individual grains are euhedral and twinned. These “eyes” compose about 20% of the thin section area. Minor structures include stylolites, fossil calcite and banding.

Insoluble residues from all specimens average 1.96%. The coarse fraction contains quartz, pyrite and muscovite. Minus 53 micron material was X-rayed and identified as illite with traces of quartz.

6. CHANNЕLED IRREGULARITIES ON THE KNOX SURFACE WOLF CEMETERY, WASHINGTON COUNTY, VIRGINIA.

L. P. Harris; *Virginia Polytechnic Institute*

In a small area 1.25 miles northeast of Shortsville, Washington County, Virginia, there are irregularities on top of the Knox dolomite which indicate the presence of an old channeled depression which are formed during an interval of temporary emergence of the sea floor in late Canadian, early Champlainian time. The evident local relief on top of the Mascot dolomite is of interest because of the clarity with which the unusual geologic relations are revealed in this locality.

7. MINERAL OCCURRENCE AND ASSOCIATIONS IN THE ALBEMARLE CRUSHED STONE QUARRY (CATOCTIN FORMATION) NEAR SHADWELL, VIRGINIA.

William F. Giannini and William K. Rector, Jr.; *University of Virginia*

The purpose of this paper is to report the mineral occurrences and associations in the Albemarle Crushed Stone Quarry. The quarry, owned by Mr. Luck, is 3.2 miles from the eastern city limits of Charlottesville, Virginia, on Route 250, near Shadwell. It is approximately 1,000 feet in length and 600 feet in width, with three terrace levels, each approximately 30 feet in height.

The minerals occurring in this quarry may be grouped into three major associations. These are the Catoctin greenstone assemblage, amygdule fillings in the greenstone, and a rhyolite dike assemblage. Those found in the Catoctin are calcite, chalcopryite with subordinate malachite, chlorite, epidote, albite metacrysts, specular hematite, magnetite crystals, pink orthoclase, pyrite, quartz, tremolite-actinolite asbestoes, and vermiculite. The majority of these minerals are secondary and occur in fractures or in distinct zones in the greenstone. Minerals in the amygdule fillings of the greenstone are disseminated specks of chalcopryite, epidote surrounding chlorite and filling the entire vesicle, and green quartz. Associated with the rhyolite dike are calcite and dolomite crystals, purple and white fluorite, hematite, and quartz, all occurring as secondary minerals filling fractures.

# 8. REMARKS ON CARBONATE-DERIVED GOSSANS NEAR STONY POINT, VIRGINIA.

J. F. Tazelaar; *University of Virginia*

Twelve miles northeast of Charlottesville, Virginia, two gossan-capped veins of Precambrian age cut Swift Run sediments. Regional tectonics produced these fissures which were subsequently healed by quartz-sulphide melts.

Both gossans have a similar mineralogy (goethite-limonite, quartz) and cavernous habit. The more prominent gossan outcrops for 1800 feet, averages 5 feet in width, is terminated and rendered schistose at its northern extreme by a strike-slip fault. Crudely aligned aplite outcrops suggest faulting of the southern extreme.

Belief that the porous gossans represented oxidation and hydration of sulphides solely has led to futile attempts to locate a supergene zone. Summarily, if sulphides (chalcopyrite, pyrite) were present their detection by an electrical survey appeared feasible. A self-potential survey was carried out and the results failed to indicate workable sulphides at depth.

Polished ore specimens reveal a late iron carbonate (siderite) replacement of pyrite (early) and chalcopyrite (late). Thus, deposition of copper sulphide was delayed, possibly prohibited, and malachite, a copper carbonate, was formed. At any rate, the cavernous to massive gossans are best explained as products of chiefly siderite oxidation and hydration, not sulphide.

# 9. PROGRAM OF THE DIVISION OF MINERAL RESOURCES.

J. L. Calver; *Division of Mineral Resources*

The Division of Mineral Resources is the division of the Virginia Department of Conservation and Development charged with the responsibility of conducting research on the geology of the Commonwealth. These responsibilities include mapping the shape of the land surface, a program carried out cooperatively with the United States Geological Survey; mapping the surface and subsurface formations and preparing geologic maps; preparation of reports concerning the occurrence, physical and chemical properties of rock and mineral materials; determination of possible industrial usefulness of these materials; and serving the citizens and industries of the State by disseminating the results of these investigations. It is apparent that the size and scope of the Division's work is indeed large.

The real endowment of the Commonwealth is still the earth and the future rests on what scientists may find in it, under it, or above it. Min-



eral resources, the rock and mineral materials below the surface and the very shape of the land itself exert an ever present influence on our everyday activities, our industrial economy, and even our way of life.

#### 10. SOME WORTHIES IN GEOLOGY.

Joseph K. Roberts; *University of Virginia*

From the time of Agricola, scholars and investigators have developed the earth sciences from mere local concern to a widespread interest. The names of Werner, Cuvier, Sedgwick, Murchison, and many others became known in America which takes us back around a century and a half.

In America Silliman, Dana, Eaton, Hall, and others early in their time set out to add to a growing and expanding science. As the years have gone by our many worthies have brought new facts from time to time, and a new geological front has been made in the last two decades. It is an expanding and a healthy advance and is penetrating most all of the regions of the earth.

As long as a free world can meet on a fair level, and interchange common knowledge there need not be local nor widespread concern over geological progress, which our worthies have started so well, and have handed down to this generation.

Each age will see, as it were, the passing and exchange of ideas by a Commonwealth of Nations. By lantern slides a selected group of worthies will be exhibited with these few words of appreciation.

#### 11. THE USE OF SILICA SAND FOR PROVIDING SKID RESISTANCE OF HIGHWAY SURFACES.

J. L. Eades; *Virginia Council of Highway Investigation and Research*

The Virginia Council of Highway Investigation and Research proved that pavement surfaces composed of limestone aggregate often become polished. To correct this condition, the Highway Department has spent over a million dollars in its deslicking program. Thin applications of skid resistant material add little to the structural strength or the durability of the road; therefore, it was necessary to find the most economical method of deslicking with very thin layers of material. One of the most effective treatments is a thin application of Kentucky Rock Asphalt which is a crushed, asphalt impregnated sandstone. This material could be applied at the rate of 10-15 lbs. per square yard. However, because the production rate of spreading was low and the initial cost of the material was high, there was a need for a better material. There was the challenge, to find a lower cost surfacing material which was just as effective when applied at the 10-15 lbs. per square yard rate.

An analysis of the rock-asphalt proved the sand grains to be very angular and almost all one size. It was learned that glass sands produced in Virginia were also very angular and had a similar gradation. Through experimentation with various asphalt contents and additives a blend was developed which could be applied as thin as Kentucky Rock Asphalt. These glass sands are now used to give the most skid resistant pavements in the state and for less money.

12. IMPLICATIONS OF SMOKY PHANTOMS IN ROCK CRYSTAL QUARTZ NEAR CRAIGSVILLE, VIRGINIA.

Whitman Cross, II and R. K. Peare; *University of Virginia*

The purpose of this paper is to report an occurrence and the possible origin of smoky quartz phantoms in some rock crystals. These crystals were found at the Gay Quarry, operated by the Lehigh Portland Cement Corporation's Fordwick Plant, approximately two miles southeast of Craigsville, Virginia on county route 684. These crystals, which are from 2 to 15 mm. in length, occur in fractures associated with clear rhombohedrons of calcite in the cherty limestone of the Upper Helderberg. The writers feel that these crystals may contribute information on the origin of some smoky quartz. Holden summarized previous work dealing with this subject in 1925. He believed the smoky color of quartz was produced by uranium-radium radiations and was not a result of carbon compounds or inorganic impurities.

Some of the smoky quartz phantoms from the Gay Quarry were found associated with smoky calcite capped by clear calcite. Such an occurrence suggests that the smoky quartz and smoky calcite have a similar origin. A thin section of a smoky quartz crystal revealed impurities in the form of layered coatings parallel to the crystal faces. The apparent smoky appearance is caused by the inclusion coatings since crystal plates, when viewed endwise, are not actually smoky in coloration, but contain only numerous oriented inclusions. The outer coatings of the phantoms are thicker than the inner layers and, in one thin section magnified 450 times, they appear to consist of microscopic crystals. These crystals are prismatic with pyramidal terminations. They have parallel extinction, birefringence, and are pleochroic with greatest absorption perpendicular to their length. These properties suggest tourmaline. Due to insufficient amounts of material, a definite identification has not yet been made.

In conclusion, the writers feel that, in some cases, quartz which is apparently smoky may result from impurity cappings on the crystals during their growth history.

13. CONJUGATE QUARTZ VEINS IN THE LYNCHBURG GNEISS NEAR FANCY GAP, CARROLL COUNTY, VIRGINIA.

B. H. Richard; *Virginia Polytechnic Institute*

Three sets of joints occur near Fancy Gap, Carroll County, Virginia. Two of these sets, which constitute a conjugate set of shear fractures, have been filled with quartz. That all joints cut the gneissosity of the Lynchburg gneiss shows clearly that the joints developed after the gneiss was metamorphosed. The joints formed in three stages: 1) a set of nearly vertical shear joints that strike N55 E developed and was filled with quartz; 2) a set of nearly vertical shear joints that strike N75 W developed, locally displaced the first, and was filled with quartz; 3) another set of joints was formed and displaced the second set with movement essentially parallel to the strike and dip of the first set. The gneiss was plastically deformed subsequent to all jointing.

14. CEMENTATION OF QUARTZOSE SANDSTONES OF WESTERN VIRGINIA.

W. D. Lowry; *Virginia Polytechnic Institute*

The cement of a few of the Paleozoic quartzose sandstones of western Virginia was introduced contemporaneously with sedimentation. The quartz grains of these sandstones, such as the hematite-cemented Clinton and the calcite-cemented Oriskany, retain much of their original shapes. In contrast, the quartz grains of the more common silica-cemented sandstones, ranging in age from Cambrian to Pennsylvanian, have had their original shapes modified or destroyed. The grains are commonly characterized by outgrowths and solution concavities. The silica cement of these sandstones was not introduced from an outside source at the time of deposition. Instead it was derived by solution of the grains themselves at points of contact where high unit stresses were developed as a result of either deep burial or major tectonic forces. The dissolved silica was deposited in lower pressure pore spaces to form outgrowths.

Although the original porosity and permeability of most of these silica-cemented sandstones has been destroyed, a few retain appreciable porosity. The incomplete welding together of these grains may be attributed to either insufficient force to maintain the required unit stress as the area of contact increased or to the driving out by gas or oil of sufficient pore water to prevent complete transfer of silica.

BUSINESS MEETING: Dr. B. N. Cooper presented a memorial in honor of the late Dr. Marcellus H. Stow, Washington and Lee University. The following officers were elected: *Chairman*—J. T. Hack; *Vice-Chairman*—J. L. Calver; *Secretary*—R. S. Mitchell; *Section Editor*—B. W. Nelson; *Historian*—J. K. Roberts.

FIELD TRIP: About fifteen took part in the annual field trip under the leadership of Dr. C. E. Sears. It was planned to be a traverse from the Blue Ridge escarpment of Floyd Co. to Sinking Creek in Giles County, but it was necessary to discontinue the trip before reaching Blacksburg because of rain.

## SECTION OF MEDICAL SCIENCES

1. A METHOD FOR THE STANDARDIZED PRODUCTION OF IRREVERSIBLE SHOCK FOLLOWING HEMORRHAGIC HYPOTENSION IN THE CAT.

Eugene D. Brand; *University of Virginia*

Eight cats were subjected to temporary hemorrhagic hypotension by means of an arterial reservoir, and their subsequent courses were followed closely until recovery or death. A level of hemorrhagic hypotension of 30 mm. Hg was found optimal, because lower pressures caused acute death from cardiac arrhythmia, and higher pressures unnecessarily prolonged the procedure. The degree of automatic reinfusion, or spontaneous uptake of blood by the cat from the reservoir, was the variable most closely correlated with subsequent development of irreversible shock. Expressed as per cent of the maximum bled into the arterial reservoir, the minimum uniformly fatal amount of automatic reinfusion was 35 per cent.

2. A RELATIONSHIP BETWEEN MOLECULAR STRUCTURE AND STIMULATION OF MUSCLE METABOLISM.

D. R. H. Gourley; *University of Virginia*

When tolbutamide (1-butyl-3-p-tolylsulfonylurea) is added to isolated frog muscle, the oxygen consumption of the tissue rapidly rises to a new rate which is maintained for several hours (*Virginia J. Science*, 8:338, 1957). The increased consumption of oxygen is due to the oxidation of excess lactate which accumulates following stimulation of glycolysis by tolbutamide. There is little or no stimulation of glycolysis when the methyl group on the benzene ring para to the main chain of the molecule is absent or replaced by either a methoxy or carboxyl radical. Substitution of an amino group (carbutamide) produces a compound that inhibits metabolism. Substitution of an ethyl, isopropyl or tertiary butyl radical produces compounds that are increasingly effective in stimulating glycolysis and oxygen consumption. These effects are similar to those caused in frog muscle by caffeine although, unlike caffeine, the sulfonylbutylurea derivatives apparently exert their effects without causing contracture.

3. THE GROWTH OF THYROIDECTOMIZED RATS GIVEN 3,3',5-TRIODOETHYRONINE.

Chalmers L. Gemmill; *University of Virginia*

Thyroidectomized rats on an iodine deficient diet have little or no growth. Neither inorganic iodide nor 3,5-diiodothyronine promotes growth in these animals. Normal diet restored partially the growth and 3,3',5-triiodo-L-thyronine restored completely the growth of the animal even after considerable time of cessation of growth on an iodine deficient diet. It is concluded that organically bound iodine is essential for the growth of thyroidectomized rats.

4. STUDIES ON THE EFFECTS OF SCURVY AND INANITION ON THE MALE REPRODUCTIVE TRACT.<sup>1</sup>

L. F. Cavazos and B. P. Kocen; *Medical College of Virginia*

Eighty male guinea pigs were divided into 20 equal groups and studied as to pathogenic effects of avitaminosis C and inanition on the reproductive system. Experimental groups were fed as follows: (a) vitamin C-deficient diet, *ad libitum*, and no ascorbic acid; (b) vitamin C-deficient diet, *ad libitum*, plus 10 mg ascorbic acid daily; (c) vitamin C-deficient diet plus 10 mg ascorbic acid daily but food consumption was adjusted in order that the animal weight would follow the weight of the scorbutic animal; and (d) vitamin C-fortified diet, *ad libitum*, plus 10 mg ascorbic acid daily. Animals on the restricted diet (c) were used to differentiate between changes brought about by caloric restriction and those induced by ascorbic acid deficiency. Staining reactions included periodic acid-Schiff technique, Sudan black B, oil red O, toluidine blue, azure A-eosin B and the ascorbic acid method.

Spermiogenesis was blocked or inhibited in the majority of the scorbutic animals and most of the inanition controls, but no changes were noted in the Sertoli cells, or connective tissue elements of the testes. There were pathologic alterations in the Leydig cells of 16 of the scorbutic animals. These changes were characterized by pyknotic nuclei, cell spindling and fibroblastic forms. Sloughed spermatids were present in the epididymis of the scorbutic guinea pigs, but were seen infrequently in the inanition controls.

5. SOME EFFECTS OF X-IRRADIATION ON GUINEA PIG BRAIN CORTEX WITH SPECIAL REFERENCE TO THE AGE FACTOR.<sup>1</sup> ....

Robert H. Brownson and Burton A. Moss; *Medical College of Virginia*

<sup>1</sup>Supported by Grant A-1181 (c) from the U. S. Public Health Service.

Certain cytological and histochemical approaches have been made towards evaluation of the effects of 1600 r units of X-ray delivered bilaterally to the animal's head. The 30 guinea pigs utilized in this study were grouped by ages into 1 month, 6 months, 9 months, 15 months, 38 months, and 62 months. Control and experimental animals were sacrificed simultaneously 32 days post irradiation time. Tissues were initially fixed *in situ* by perfusing with 10 percent formalin and physiological saline-acacia. Further fixation was then carried out.

Control animals demonstrated higher counts of perineuronal glial satellite cells than experimental animals. Average numbers of glia/neurons for all control animals was 0.90 and for the experimental, 0.70. Identification of types of perineuronal glial satellite cells demonstrated that in controls 63 percent were oligodendroglia, 22 percent astrocytes, and 15 per cent microglia. Experimental animals indicated a decrease in microglia and increase in oligodendroglia.

The Feulgen reaction revealed in experimental animals 1) that neurons exhibited conspicuous Feulgen positive granules approximating the nuclear membrane; 2) in glial cells, alteration of the staining pattern from the control animals. Hortega's silver carbonate method for pigment, osmic acid method for degenerating myelin and phase microscopic analysis will be discussed.

6. MOTION PICTURES OF CHANGES IN CELLS INDUCED BY X-RAY TREATMENTS OF TADPOLES AND TETRAHYMENAE.

Carl C. Speidel; *University of Virginia*

7. TISSUE CULTURES FROM HUMAN ADULT BRONCHIAL EPITHELIUM.

Cornelia Hoch-Ligeti and Joyce P. Hobbs; *University of Virginia*

Explants of bronchial epithelium were made *in vitro* from 140 adult human lungs removed by operation. Apparently normal bronchial epithelium taken from patients with carcinoma of the lung grew more often in primary explants than analogous epithelium from tuberculous patients or from patients with bronchiectasis or unresolved pneumonia. The histological appearance of the bronchial epithelium of the donor, even in a segment immediately distal from the explant, did not give an indication of the facility with which the explants could be grown. Explanation of carcinoma of the bronchus was unsuccessful in 4 cases. Two explants both derived from cases of carcinoma of the lung, gave rise to permanent cell strains. The cells of the two permanent strains, growing in clones, assumed the morphological appearance of malignant cells during the 12 months of cultivation. Their histochemical behavior with regard to reduction of tetrazolium salts was also changed. When trans-

planted into cortisone-treated weanling rats, these cells grew for 3-4 weeks and invaded the surrounding muscles, however, no metastatic lesions were observed.

8. EFFECT OF AMPHENONE ADMINISTRATION OF THE ADRENAL RESPONSE OF RATS TO ALCOHOL INTOXICATION.

J. C. Forbes and G. M. Duncan; *Medical College of Virginia*

Amphenone (1,2-bis-(p-aminophenyl)-2-methyl-propanone-1-dihydrochloride) was fed for 7-14 days to half-grown male rats at a level of 0.5% in a diet consisting of equal parts ground pellets and complete synthetic diet containing 65% sucrose. The adrenal cholesterol concentration increased progressively to about 4 fold by 14 days, concurrently with marked hypertrophy of the glands. The drop in the adrenal cholesterol in response to alcohol intoxication was either absent or markedly inhibited. The rate at which relatively unresponsive adrenals developed seemed to be a function of the initial age as indicated by weight of the rats and of the number of days amphenone was fed. The extent and duration of intoxication was quite comparable to that seen in control rats. Amphenone feeding did not influence the rate at which alcohol disappeared from the blood.

9. A "NEW" AUTOAGGLUTININ AGAINST STORED ERYTHROCYTES.

Cecil Hougie, Janet L. Dandridge and O. B. Bobbitt; *University of Virginia*

A high-titer autoagglutinin directed against stored erythrocytes was found in an elderly patient with a hemolytic anemia. The patient's serum agglutinated her own and all ABO compatible cells which had been stored for 72 hours with or without anticoagulants. The agglutinin had a wide thermal amplitude between 2 and 37° C, with an avidity greatest at 37° C, and was present to a titer of 1 in 4000. Fresh cells exposed to a pH of 6.2 for 1 hour or papainised cells were also agglutinated. The agglutinability of stored cells could be reversed by treatment with adenosine and inosine. The agglutinin was relatively heat stable and no loss of activity occurred after heating to 56° C for 30 minutes, but almost complete inactivation was achieved by heating to 70° C for 2 minutes. The patient's direct and indirect Coombs tests were negative, and the indirect Coombs performed on stored cells exposed to high non-agglutinating titers of the patient's serum were also negative using 4 different types of Coombs sera. This agglutinin differs from any other hitherto reported.

# 10. EFFECT OF TEMPERATURE ON SECRETORY ACTIVITY AND OXYGEN CONSUMPTION OF ISOLATED FROG SKIN.

Ernst G. Huf and Norma S. Doss; *Medical College of Virginia*

A study is presented on the effect of temperature on unidirectional active ion transport, resting electrolyte equilibrium (electrolyte composition) and oxygen consumption in isolated frog skin. The aims were two-fold; first, to find out whether the rate of active transport can be changed without affecting the  $\text{Na}^+$  and  $\text{K}^+$  balance of skin itself; secondly, to arrive at minimal  $\Delta \text{Na}^+/\Delta \text{O}_2$  values by correlating quantitatively inhibition of active ion transport with inhibition of  $\text{O}_2$ -consumption.  $\text{NaCl}$  transport was maximal at  $20^\circ \text{C}$ . At  $28^\circ$  and at temperatures below  $20^\circ$ , rate of  $\text{NaCl}$  transport was diminished. In many instances  $\text{NaCl}$  transport was diminished in skins which maintained their normal  $\text{Na}^+$  and  $\text{K}^+$  content. In several cases, however, neither rate of transport nor resting electrolyte equilibrium was affected; in other cases both were.

$\text{O}_2$ -consumption decreased when lowering the temperature over the range from  $28^\circ$  to  $10^\circ \text{C}$ . From a plot of  $\log Q_{\text{O}_2}$  against  $1/T$  an activation energy of  $\mu = 13,700 \text{ cal}$  was calculated, valid for the range from  $10^\circ$  to  $20^\circ \text{C}$ . It appeared that  $\mu$  was smaller for temperatures about  $20^\circ \text{C}$ . Working between  $10^\circ$  and  $20^\circ$ , it was found that, on the average, 4 to 5 equivalents of  $\text{N}^+$  were transported for one mole of  $\text{O}_2$  consumed in skins with undisturbed resting electrolyte equilibrium.

# 11. A CELL FOR OSMOSIS AND DIFFUSION STUDIES OF ISOLATED SECRETORY MEMBRANES.

Addison D. Campbell, Thomas E. Gilmer and Ernst G. Huf; *Experiment Incorporated, University of Richmond and Medical College of Virginia*

A cell, 10 inches long and 3 inches in diameter, has been constructed of lucite and consists of two nearly identical halves. When the membrane is held in the cell, it separates two chambers of 30 cc each, in which is placed the material to be studied. Connections to current electrodes are provided at the ends of these chambers thereby furnishing a means of setting up a current in the cell and, thus, controlling the potential difference across the membrane. Another pair of electrodes, located at the membrane, allows for the measurement of this potential. Both sets of electrodes are connected to the auxiliary circuit through calomel electrodes. The cell is further equipped with connections for osmometers, means of filling and draining the chambers, magnetic stirrers, and is surrounded by a water jacket for temperature regulation. Tests show that the potential over the area of the membrane is constant to within 1 mv and the temperature is constant to  $\pm 0.02^\circ \text{C}$ .



12. AN APPARATUS FOR THE STUDY OF ISOLATED SECRETORY MEMBRANES AT AUTOMATICALLY CONTROLLED MEMBRANES POTENTIALS.

Thomas E. Gilmer, Addison D. Campbell and Ernst G. Huf; *Experiment Incorporated, University of Richmond and Medical College of Virginia*

An apparatus is described which automatically and continuously controls the potential across an isolated membrane in a conducting liquid. Potential probes adjacent to the membrane on each side provide the means for measuring the potential; this signal is also used as the input to a servo amplifier. The servo amplifier in turn operates a motor-driven slide-wire which varies an applied voltage to produce a null signal at the input. This voltage is applied through suitable electrodes across the ends of the chamber containing the liquid and membrane.

The servo amplifier, motor and slide-wire are adapted from a standard Varian Model G-10 strip-chart recorder. The alterations to the recorder are in the circuit and in the gearing between motor and slide-wire. A motor-driven micro switch makes possible the automatic alternate measurement of spontaneous membrane potential and current at controlled potential.

Results are given of a series of measurements made on frog skins in Ringer solution; the effect of the addition of various inhibitors on the spontaneous potential and the short circuit current is shown. The apparatus can be used in conjunction with radioactive tracer studies to give an accurate measure of the total energy associated with active ion transport.

13. METABOLIC STUDIES ON ISOLATED EPITHELIUM OF FROG SKIN.

Leif Skjelkvale, Kathryn Nieder, and Ernst G. Huf; *Medical College of Virginia*

The aims of the present study are to investigate the effect of: (1) Krebs cycle metabolites and related compounds on  $O_2$  consumption of intact skin epithelial cells; (2) enzyme inhibitors in the presence and absence of substrates on  $O_2$  consumption; (3) substrates (shown to be effective on  $O_2$  consumption) on net rate of active  $Na^+$  transport by measuring the electric current output of isolated, intact skin. To remove the epithelium, pieces of abdominal skins were kept overnight in the cold room in a small volume of bicarbonated water ( $pH = 7.0$ ). Histological evidence is presented to show that all layers of a well-preserved epithelium can be removed by gently scraping the surface of skin, pretreated as mentioned. Mineral analysis showed that treated skins had reduced their  $Na^+$  and  $K^+$  content to about  $1/2$  of the original values; water content was slightly elevated. Nevertheless, a vigorously respiring isolat-

ed epithelium could be obtained.  $QO_2$  measurements on isolated epithelium (using the Warburg technique) in the presence and absence of 100 units of penicillin and 100  $\mu$  gm streptomycin showed that for a period of at least 4 hours all  $O_2$  is consumed by epithelial cells, — not by micro-organisms that might have been present. Pyruvate and oxalacetate (0.1 — 5 mM) increased  $O_2$  consumption. Oxalacetate (5 mM; the only substance tested so far) was also able to increase (40% for 6 hours) the electric current output as a result of increased active  $Na^+$  transport. Fluoroacetate significantly depressed  $O_2$  consumption. Sodium acetate was able to protect against fluoroacetate but only when present before addition of fluoroacetate.

#### 14. ION ACTIVITIES WITH PRESENCE OF KIDNEY BRIES.

Sidney Solomon; *Medical College of Virginia*

#### 15. METABOLISM OF NICOTINE IN THE HUMAN.<sup>1</sup>

Edward R. Bowman, Lennox B. Turnbull, and Herbert McKennis, Jr.;  
*Medical College of Virginia*

In previous studies from this laboratory [J. Am. Chem. Soc. 79, 6342 (1957)] urine of dogs, following intravenous administration of nicotine, was examined for metabolites. Examination of male human urine after oral administration of nicotine (30 mgm/per day for three days in divided doses of 3 mgm each) and examination of male smokers' urine has now been accomplished through similar techniques. The urine of smokers is similar to that of nicotine-treated dogs in that the chloroform soluble metabolites upon paper chromatography with 0.5 N ammonia water — (1 vol.) -n-butanol (4 vol.) -ethanol (1 vol.) separate into three Koenig positive zones ( $R_f$  0.61, 0.73, 0.86). In addition to these metabolites, a zone corresponding to unchanged nicotine is observed. This latter finding confirms the work of earlier investigators. The  $R_f$  0.73 material from the chloroform extract of a human volunteer who ingested nicotine was purified by chromatography on alumina and passage through a Dowex-1 (OH) column. An oily fraction obtained from this operation readily yielded a yellow picrate (micro m.p. 100-102°) corresponding to cotinine picrate. The infra red absorption spectra of authentic and isolated picrates were identical. The mixed melting point showed no depression. The involvement of cotinine in the metabolism of nicotine in the human points to the probably occurrence of other metabolites, including  $\gamma$ -(3-pyridyl)- $\gamma$ -methylamino-butyric acid, and other compounds which can arise from nicotine via the metabolic intermediate cotinine.

<sup>1</sup>Aided by grants from the Tobacco Industry Research Committee and the American Tobacco Company.

## SECTION OF PSYCHOLOGY

## 1. A FOLLOW-UP STUDY OF SCHOOL RELATED REFERRALS.

Roberta Keifer Simmons; *Norfolk Mental Hygiene Center*

This study was intended as an evaluation of the work of the Norfolk Mental Hygiene Center in reference to cases of maladjusted or disturbed school children referred either directly from the area school authorities or from other agencies. The investigation was carried out by means of a questionnaire completed by the visiting teachers engaged upon the follow-up study. The information on 46 completed questionnaires was classified and tabulated yielding summary data presented in table form under such headings as: age, sex and grade; referral sources; recommendations effected and not effected; other action taken; present condition; further action recommended; and comments concerning the present status of the case. From this information it has been possible to draw conclusions concerning the efficacy of both the clinic and school services together with recommendations for improvements in these services as well as the use of the follow-up technique.

## 2. VARIATION OF WHOLE-PART METHODS OF LEARNING AND EXPERIMENTERS.

F. J. McGuigan; *Hollins College*

McGuigan and MacCaslin have suggested that much of the superiority of the whole method may be due to the fact that it entails greater distribution of practice than does the part method. The present study sought to further vary the amount of distribution and simultaneously the extent to which the method is whole or part. A second purpose was to sample a population of experimenters.

Seventy-two undergraduate women served as subjects and nine as experimenters. The task used was the reproduction of a kuo block task. Four methods were: a part method, a very incomplete whole method, an incomplete whole method, and a whole method. Hence a 9 x 4 factorial design was used.

The results were: No significant difference among experimenters; a significant difference among methods such that the whole method was superior to the others, and the incomplete whole method was superior to the incomplete whole method and the part method. Hence these results are in accord with the McGuigan and MacCaslin hypothesis and indicate that generalization to the population of experimenters is tenable.

### 3. CUTANEOUS ELECTRICAL $\Delta$ I.

Glenn R. Hawkes; *University of Virginia*

In the University of Virginia Psychological Laboratory there has been devised a cutaneous communication system using a matrix of mechanical vibrators to impart encoded information to a subject. While it is theoretically possible to design such a system using electrical stimuli to produce vibratory sensations, almost no published research data report cutaneous sensitivity to electrical current. Intensity of stimulation is a cue used in the mechanical communication system, but no information is available on sensibility to electrical current intensity changes. This research was an investigation of cutaneous sensitivity to changes in alternating current intensity.

The possible effect of differing frequencies of stimulation was determined by use of 100, 500, and 1500 cycles per second of alternating current. Data are not yet complete, but the effect of different frequency appears small, a result comparable with research using mechanical vibration.

The effect of weak or strong levels of the standard on discrimination of intensity changes was investigated by using a standard level just above the absolute threshold and a standard just below the tolerance limit. The effect of different intensity levels of the standard is small; published results using mechanical vibration show considerably better discrimination at strong intensity levels of the standard than at weak intensities.

### 4. CUTANEOUS FREQUENCY DISCRIMINATION.

Genevieve Dugan Goff; *University of Virginia*

To measure the ability to discriminate differences in frequency of a cutaneous vibratory stimulus, it is imperative that cues from concomitant changes in subjective intensity of the stimulus be eliminated. This was done in the present study by finding for each frequency used the intensity which rendered that frequency subjectively equal in intensity to a 100 c. p. s. standard. Each of four observers used made these equal intensity judgments for two intensity levels of the standard — 25 d. b. and 35 d. b. above threshold. Using the individual equal intensity curves thus obtained, each observer then made judgments of differential frequency for 25, 50, 100, 150, and 200 c. p. s. Curves are presented for one observer showing the equal intensity and differential frequency values. Differential frequency was found to increase with frequency and to decrease with intensity.

## 5. LOGICAL REASONING AND SCIENTIFIC TALENT.

Antonia Bell Morgan; *Merrifield, Virginia*

The Morgan Test of Logical Reasoning was given to the 40 winners of the Westinghouse Science Talent Search in 1957 and again to the 40 winners in 1958. A statistical analysis of the results of these 80 winners and a comparison of the scores of these winners with other groups reveals that these high school seniors, as a group, are more logical in their reasoning than college graduates with a Bachelor's degree, college graduates with a Master's degree, college graduates with formal training in logic, supervisory employees in a large corporation, engineers with a Bachelor's degree, college graduates with a law degree, and distinguished college graduates selected by a Government agency for training as executives. The conclusion is drawn that one aspect of science talent is marked ability to reason logically. A corollary conclusion is that this may prove useful in the detection of scientific talent at the high school senior level.

## 6. STIMULATING DISCOMFORT AND RELIEF IN WRITTEN DOCUMENTS.

Dell Lebo and William Applegate; *Richmond Professional Institute*

The Discomfort Relief Quotient has been employed frequently as a reliable measure of tension during psychotherapy. An examination of experimental work reveals a close correspondence between discussion topic and DRQ tension. Early in therapy, when a great number of problems are mentioned, DRQ's are high. Later, when the patient states fewer problems, lower DRQ's occur. This systematic relationship can be discerned under a variety of conditions. Despite this close relationship, the specific role of topic as determinant of DRQ seems to have been largely overlooked.

To investigate this relationship specifically 55 women were asked to write about three topics; an unhappy, happy, and "neutral" event. It was hypothesized that DRQ magnitudes could be produced to order: low, high, and intermediate for unhappy, happy, and "neutral" event stories respectively.

The hypothesis was borne out. Two implications arise. This method is promising; it can be used to rapidly and easily compare DRQ's with other objective measures of tension. The utility of DRQ measures as evidence of therapeutic success may be limited by their tendency to reflect the discussion topic. A counselor could influence the DRQ at will.

## 7. THE CONTROL OF OLFACTORY STIMULI.

William R. Goff; *University of Virginia*

Extensions of a previously reported technique for studying olfactory

sensitivity in small animals are presented. A simplified system of successive dilutions has been devised which permits the presentation of accurately quantified odor vapor stimuli in concentrations of one part in one million or lower. This technique is being used to determine the absolute threshold of the albino rat to a series of homologous hydrocarbons.

#### 8. THE DEVELOPMENT OF THE IOWA PICTURE INTERPRETATION TEST.

Robert A. Johnston; *University of Richmond*

This paper reviews the development of the Iowa Picture Interpretation Test, presenting the rationale and a description of the four scales which it includes. Its history is traced through several revisions with data concerning its reliability and validity. Also included is a review of the literature concerning the achievement scale of the IPIT and a summary of the theoretical and methodological considerations surrounding its use. Its purpose is to provide a background for both a critical consideration of the IPIT as a useful instrument for the assessment of the achievement variable and a better understanding of the research papers to be presented in the symposium.

#### 9. A FURTHER INVESTIGATION OF THE EFFECTS OF ACHIEVEMENT IMAGERY AND DIFFERENTIAL INSTRUCTIONS ON MAZE-LEARNING PERFORMANCE.

Ann Hunter; *University of Richmond*

Two studies investigating the effects of Achievement Imagery (AI) and motivational instructions on the learning of an electric maze had yielded conflicting results. In the initial study, it was found that there were no differences between high and low AI Ss under threat of shock instructions; while under neutral instructions, the high AI group made significantly fewer errors. A replication of this study, however, showed that high AI Ss made more errors than low AI Ss under shock instructions and that there were no differences under neutral instructions. The replication also yielded sex differences which were not found in the original study.

The present study attempted to resolve these conflicting results. Certain differences in procedure were also investigated, as was the general learning ability of the Ss in the AI groups. In general, the results lend more support to the conclusions of the second study.

#### 10. A PSYCHOLINGUISTIC ANALYSIS OF SPEECH BEHAVIOR IN GROUP DIFFERING IN ACHIEVEMENT IMAGERY.

Rudolph F. Wagner; *Richmond Public Schools* and John E. Williams;  
*University of Richmond*

This study was designed to investigate experimentally whether a psycholinguistic analysis would reveal any characteristic differences in the speech behavior of Ss with High and Low Achievement Imagery (AI) as measured by the Iowa Picture Interpretation Test (IPIT). A further variable was introduced in form of the K-Scale of the Minnesota Multiphasic Personality Inventory (MMPI) in an attempt to refine the measurement of Achievement Imagery. Forty-four male college freshmen were divided into High and Low AI Groups. The two AI groups were then subdivided into High and Low Defensiveness Groups on the basis of the K-scale scores, yielding four subgroups in all. Ss were given verbal cues and their verbal responses were recorded and subsequently subjected to a psycholinguistic analysis. In the comparisons of High and Low AI Ss, the category of "nonfluencies" was the only one that yielded a statistically significant difference. No categories proved significant when High and Low Defensiveness groups were compared and no interaction effects between AI and K were found.

11. ACHIEVEMENT IMAGERY AND A. C. E. SCORES AS PREDICTORS OF GRADES IN GENERAL PSYCHOLOGY.

John E. Williams; *University of Richmond*

The study investigated the relationship of differences in Achievement Imagery (AI), measured by the Iowa Picture Interpretation Test, and differences in "academic aptitude", as measured by the A. C. E. test to academic standing at the end of the first semester of a course in General Psychology.

The major findings were, as follows: for women, high AI was associated with higher grades at all levels of academic aptitude with the most pronounced relationship in the middle range of aptitude; for men, AI was not associated with grades at any level of academic aptitude.

12. PUPILLARY DILATION TO SPECTRAL STIMULI.

Robert H. Gibson; *University of Virginia*

An indirect method of correlating differential retinal sensitivity with wavelength of light stimulation has been described by Motokawa. He has reported that temporal change in retinal sensitivity, as measured by the magnitude of DC pulse required to produce a barely discernible phosphene flash, is related to the color of a two-second preadapting photic stimulus. His suggestion is that the obtained differentially shaped recovery functions represent the aftereffects of the three basic receptor

systems for color, in accordance with the trichromatic color theory.

The present exploratory study was an examination of the time course of photopic pupillary dilation to red, green, blue-green, and white light of equivalent photometric brightness. Two levels of brightness were employed for one of the colors. Since the pupillary reflex is closely related to many retinal states, the form of the dilation function was examined for differences attributable to wavelength of foveal stimulation. No such differences were found; intensity (brightness) was judged to be the significant variable.

13. A COMPARISON OF PATTERNS OF DRINKING BEHAVIOR IN RATS FOLLOWING WATER DEPRIVATION AND SALINE INJECTION.

James F. Campbell, Jr.; *University of Virginia*

Several investigators have reported using injections of predetermined doses of hypertonic saline to produce drinking behavior in the rat equivalent to that obtained following specified periods of water deprivation. The typical basis of comparison has been the total amount ingested during a test period.

In a preliminary experiment employing a modified Stellar drinkometer the number of laps were cumulatively recorded to determine the patterns of drinking for six rats during a one hour period after either 24 hours water deprivation or injection of a ten percent saline solution.

While the total amount drunk was comparable under each condition, the deprived animals drank in an initial burst of about 500 laps followed by brief pauses and short bursts of 30 to 40 laps for the remainder of the hour. The injected rats, subsequent to a similar initial burst, stopped for a longer interval and then took 200 to 250 laps. The rats which were switched from a deprivation to an injection schedule changed patterns of drinking, but the initially injected did not.

Current studies are attempting to determine the cause of the failure to reverse as well as to answer other questions about these phenomena.

14. THE PARENTAL PATHOGENS TEST.

Harold E. Paine; *Memorial Guidance Clinic*

The Parental Pathogens Test is a thematic apperception type of projective technique employing ambiguous stick figures and specifically structured verbal directions. It was originally designed to get at certain pathogenic parent-child relationships. This is an introduction of a technique for which no formal normative or validating data are available. Clinical experience with it indicates that it can be a reliable, valid, and useful instrument.



It has been observed that the test reveals, in addition to the specific pathogens: family and life role, self-concept, kinds of self-expression and communication characterizing the family, the nature of interpersonal relationships, and the defense mechanisms.

The PPT is regarded as being most useful in "middle childhood" (6-12 years). It shows promise of special significance for understanding the child within the context of his total family inter-relationships.

#### 15. WHO IS THE PATIENT?

A. W. Jeffreys; *Western State Hospital*

Traditionally the psychotherapeutic treatment of psychosis is administered primarily to the patient, while significant relatives and friends enter little, if any, into the treatment process. The importance of treating significant people in the patient's life is becoming more recognized and in some instances realized. In therapy with children, the value of treating parents has always been recognized and even demanded by some clinics.

The author cites three cases where improvement of adult psychotics followed treatment of adults significant to the patient. Should such an approach prove fruitful, a very serious question arises within our society as to who should receive treatment — the carrier of the symptoms or the person (or persons) who enters into the generation of the symptoms. Most often the latter exhibits no behavior or symptoms that would allow for enforced treatment under the present value system of our society.

#### 16. A REPETITION OF THE MILLER EXPERIMENT ON ACQUIRED FEAR.

Raymond H. Kirby; *The College of William and Mary*

An experiment by Myers and Miller (1952) had demonstrated that the Miller (1948) demonstration of fear as motivation and fear-reduction as reinforcement lacked a necessary control for "exploratory" behavior. It was the purpose of this experiment to repeat the original Miller experiment with a control group.

A group of ten white rats was trained and tested using the same procedure employed by Miller in 1948. Another group of ten white rats, the control group, was given the same procedure except that they received no shock on the fear-acquisition trials.

Using the measure of latency to turn a wheel to escape the compartment in which the rats had a history of shock, the experimental group was found to have more responses of escaping and shorter mean latencies for escape.

The data were interpreted as supporting the conclusions of the 1948 Miller experiment — i. e., that fear can be motivating and fear-reduction can be reinforcing.

17. AN APPARATUS FOR STUDYING VARIABLES OF HUMAN TASTE THRESHOLDS.

John B. Feallock; *University of Virginia*

Three variables are discussed which are likely to have effects upon taste processes and are capable of being studied peripherally in man. These are the temperature of the taste solution, the interaction of temperature with taste quality, and the rate at which a taste solution flows over the tongue. The substance of this paper is the description of an apparatus that will permit the control of these variables in the study of their effects upon absolute thresholds of taste.

The tongue is stimulated by means of a modified Gustometer through which the taste solution flows by gravity feed at a constant rate. The rate is determined by one of a series of constricted tubes calibrated for rate of flow which is placed in the flow line. The rate of flow may be varied up to 1.6 ft/sec by this means, and is accurate to within 5% over most of this range.

The temperature of the stimulus solutions and rinse water is held constant through the use of a thermostatically controlled water bath, water jacket, and heating coils. Temperature control is completely automatic and accurate to within  $0.5^{\circ}\text{C}$  at the point of stimulation for temperatures within the range of  $20-45^{\circ}\text{C}$ .

18. LENGTH OF DEPRIVATION AND TIME OF TESTING AS DETERMINANTS OF FOOD INTAKE.

George Cicala and John K. Bare; *College of William and Mary*

The authors have previously demonstrated that if deprivation is *begun* at 1900 hours and extended for varying durations up to 24 hours, the subsequent 24-hour intake of white rats is determined to such an extent by their natural day-night cycle that deprivation fails to increase ingestion. The present study provides similar long term measures of food intake when deprivation is *terminated* at a fixed time.

White rats were subjected to a single deprivation and taught to press a lever to secure food on a continuous reinforcement schedule. Thereafter, the animal received all his food by performing this response. After 72 hours of acclimatization, seven groups of eight animals each were deprived for 0, 2, 4, 8, 12, 18, and 24 hours. For half the animals in each group, deprivation was terminated at 1900, and for the other

half deprivation ended at 1300. Food intake was measured for 24 hours following deprivation.

During the first hour of eating following deprivation, intake increases significantly as deprivation increases and time of testing fails to influence the behavior. Thereafter, both testing time and length of deprivation significantly alter food intake, and no interaction is apparent.

## SECTION OF SCIENCE TEACHERS

1. The Science Teachers Section of the Academy was addressed by Mr. Frank Kizer of the State Department of Education on the methods this organization is now using to help the science teacher in Virginia.

2. Dr. James W. Cole, Jr. moderated a program on Quantitative Measurements in the Teaching of Science. Different members of the Academic Year Institute presented phases of measurements applicable to the fields of chemistry, physics, and biology.

In chemistry, Mr. William Karnes acted as host and presented Mrs. Edna Luck and Miss Natalie Holladay who demonstrated methods of measuring density, and from this, methods of calculating the percentage of metals in alloys.

Mr. James Benton and Mr. Karnes presented a time reaction study on chemical reactions and plotted a graph of the results.

In physics, Mr. Harlan Pafford served as host, Miss Ruth Carter explained the equipment, and Mrs. Mariana Becker demonstrated that Ohm's Law is not always correct. Mr. Pafford showed how graphs of such information could be plotted.

In biology, Mrs. Ashley Morgan demonstrated how quantitative measurements can be used in biology in measuring the size of simple plants and animals and in calculating the reaction of the number of molecules in the photosynthetic reaction.

Mr. Ramon Davis illustrated how the concentration of  $P_{32}$  was detected in coleus stems and leaves. The effects of  $P_{32}$  causing anemia in mice was also shown. Graphs were used to demonstrate the differences.

The following officers were elected for next year. They are: Mae Jennings, *Chairman*; A. B. Niemeyer, Jr., *Chairman-elect*; Virginia Ellett, *Secretary*.

## SECTION OF STATISTICS

1. COMBINED INTRA- AND INTER-BLOCK ANALYSIS FOR FACTORIALS IN INCOMPLETE BLOCK DESIGNS.

R. E. Walpole; *Roanoke College*

The work of Kramer and Bradley on factorials in incomplete block designs has been extended to include the several suitable classes of two-associate class, partially balanced incomplete block designs, that have not at present been considered in the literature. For the balanced incomplete block and the group divisible, partially balanced incomplete block designs, only the combined intra- and inter-block analysis is considered. However, in the case of the Latin Square, partially balanced incomplete block designs, both the intra-block analysis and the combined intra- and inter-block analyses are obtained.

A study is made of the variances and covariances of the factorial estimators, and then of factorial treatment contrasts, along with the efficiencies of the contracts in various designs relative to the corresponding contrasts in completely randomized designs. Tests of significance for factorial effects are derived and single-degree-of-freedom comparisons are determined in order to investigate trends and special contrasts among the factorial effects.

2. THE USE OF RESPONSE SURFACE ANALYSIS ON BIOLOGICAL MATERIAL.

David C. Hurst; *Virginia Polytechnic Institute*

Traditional analyses of variance on continuous treatments are compared with the response surface formulation. Pitfalls in the use of the response surface technique on biological material in bioassay and fertilizer experiments are pointed out. Some remedies are suggested.

3. TRIANGLE, DUO-TRIO, AND DIFFERENCE-FROM-CONTROL TESTS IN TASTE TESTING.

Ralph A. Bradley; *Virginia Polytechnic Institute*

Much experimental work has been done in comparing triangle and duo-trio tests for the detection of differences in taste testing. Some of the mathematical implications have also been discussed by Hopkins and Gridgeman [Biometrics 11(1)]. In this paper we assume subjective responses on a response scale and develop means of calculating corresponding probabilities of correct choices in triangle and duo-trio tests and expected difference from control in the difference-from-control test. The two probabilities mentioned above are expressed in terms of the power

function of analysis of variance but required special evaluations in this problem. A table showing comparisons of the several tests is presented and from these power comparisons and power efficiencies may be evaluated.

4. INTRODUCTION TO STATISTICAL SAMPLING INSPECTION.

G. F. White, Jr.; *Richmond Professional Institute and Reynolds Metals Company*

Sampling Inspection involves the inescapable risk of making wrong decisions. Fortunately, the risks involved in sampling can be specified in advance and plans found or designed that will control these risks at economic levels. The two fundamental curves (Operating Characteristic and Average Outgoing Quality) showing the protection Characteristics of a plan and the Average Sample Number curve showing cost characteristics of a plan are described. The essential steps in selecting and applying statistical sampling plans are discussed.

5. APPLICATION OF VARIANCE-LENGTH CURVES IN PRODUCT QUALITY ANALYSIS.

William D. Hicks; *Fieldcrest Mills, Incorporated*

The variations in linear weight of sliver, roving and yarn were evaluated in terms of the variance-length curve. It was found that the variance-length curve is a means of completely characterizing the weight variation in a strand of textile product. After discussing the method of sampling and testing, the statistical techniques of combining cut lengths to obtain all the requisite points on the variance-length curve are presented. An example of a typical set of results is included.

This paper is based on a thesis submitted by the author in partial fulfillment of the requirements for the M. S. C. degree at the Institute of Textile Technology, June 1957.

6. METHODOLOGY FOR THE IMPROVEMENT AND ANALYSIS OF UNSATISFACTORY CONDITION DATA ON A COMPLEX AUTOMATIC ELECTRO-MECHANICAL SYSTEM.

James R. Duffett; *Virginia Polytechnic Institute*

This paper provides the following methodology:

- (1) Non-statistical methods which can be implemented without delay to improve an Unsatisfactory Condition Reporting System on a Complex Automatic Electro-Mechanical System.
- (2) Methods of statistical analyses which can be employed to evaluate reliability and quality when "common denominators", such as component operating time and hardware complexity, are not available.

- (3) Methods of statistical analyses which do require the availability of such "common denominators" as component operating time and hardware complexity.

The ultimate purpose of the methodology given is the evaluation and improvement of the reliability and quality of the hardware.

#### 7. ANALYSIS AND REDUCTION OF VARIATIONS IN THE PROCESSING PLANT.

Norbert Lloyd Enrick; *Institute of Textile Technology*

In many types of processing, such as occur in the chemical and textile industries, it is desirable to determine the amount of variability present at each production stage. From this determination, it is then possible to isolate those places where excessive variation may be occurring, and which may then be corrected.

This type of variations analysis is often complicated by the fact that there may be several machines at one processing stage, which may feed randomly into the machines of the subsequent department. For example, in cotton or synthetic fiber carding, the product from 50 to 100 cards may feed randomly into 5 to 10 drawing frames, being mixed in the process. Variance analysis may be utilized to break down processing variations at each stage into the within-machine, between-machine and room-overall components. Further statistical evaluations can then be made to allow for the effect of mixing and blending, as well as for the effect of attenuation, draft, or dilution of stock.

In order to make these statistical tools useful in a plant that may not have the continuous services of a statistician in the laboratory, a simplification has been developed, utilizing average within-machine and cross-ranges as estimates of variance components.

From a large number of actual applications of this technique, a typical example is used, illustrating how the within-machine, between-machine and room-overall components of variation may be evaluated and utilized to isolate and subsequently correct places in processing where excessive variations are occurring. This example involves the tracing of the flow of variations from process-to-process for five successive processing stages, involving mixing and blending, as well as attenuation of the stock processed.

#### 8. APPLICATION OF LINEAR PROGRAMMING TO DOPE METERING PUMP REPLACEMENT.

J. W. Cowdery; *Celanese Corporation of America*

Three types of pumps, each capable of producing any of the ten dif-

ferent products manufactured at the plant, were assigned to the products, by Linear Programming techniques, to effect the minimum replacement costs. Collection of the necessary data (failure rates, replacement costs, and product mix) was the most difficult phase of the application. Due to practical limitations in plant operation the optimum solution could not be applied; however, the solution was used to formulate a set of operating rules. Operation of the plant to these rules resulted in a considerable reduction in replacement costs.

#### 9. A DESIGNED EXPERIMENT TO EVALUATE YARN LUBRICANTS.

Hubert M. Hill; *Tennessee Eastman Company*

This paper will describe an experiment to compare seven yarn lubricants and two yarn sizing formulations.

In order to evaluate the lubricants, the yarn was prepared on warp beams and woven into cloth. The lubricants were evaluated by inspecting the cloth for warp defects.

The design used was a  $2 \times 7$  factorial replicated three times.

In order to finish the experiment in a reasonable time, the experiment was run on seven looms in blocks of six using a partially balanced incomplete block design with two associate classes.

Prior to analysis the average value for each treatment was transformed as the  $\sqrt{x}$ .

Analysis of the data showed that the lubricants can be divided into two over-lapping groups. Neither the sizes or interactions were significant. The choice of the transformation used and certain aspects of the data also will be discussed.

#### 10. ANALYSIS OF VARIANCE OF A RANDOMIZED BLOCK DESIGN WITH MISSING OBSERVATIONS.

William A. Glenn and Clyde Y. Kramer; *Virginia Polytechnic Institute*

The estimation of several missing values in a randomized block design is considered. The method used is that of minimizing the error sum of squares, proposed originally by Yates (1933). Explicit equations for each absent value are derived for all cases in which not more than three values are missing. A general formula valid for any permissible number of missing observations is given for the case in which no two values are missing in the same block or treatment, and also for the case in which all of the values missing are in a single block or treatment. A procedure for the completely general case is proposed. This, although requiring the inversion of a symmetric matrix of order equal to the

number of missing observations, may prove to be less tedious in application than the iterative method proposed by Yates.

A direct method of analysis not requiring a correction for bias in the treatment sum of squares is discussed and demonstrated. Formulas are given for the bias introduced when an analysis of variance is carried out on the augmented data. These, though equivalent to the generalized formula given by Yates, are found to differ from the latter slightly in form.

#### 11. ANALYSIS OF VARIANCE OF A LATIN SQUARE DESIGN WITH MISSING OBSERVATIONS.

Suzanne Glass and C. Y. Kramer; *Roanoke College and Virginia Polytechnic Institute*

The statistical analysis of a Latin square design is sometimes complicated by the fact that some of the observations are missing. The usual method of analysis requires that the design be balanced, but missing values destroy this property of balance.

In this paper, a method is developed for analyzing a  $k \times k$  Latin square with  $p$  missing observations,  $1 \leq p \leq (k-1)(k-2)-1$ , where only one missing plot appears in any row, column, or treatment or where all the missing values appear in the same row, column, or treatment.

Explicit formulas for the  $p$  missing plots are obtained as well as formulas that may be used to correct for the bias in the treatment sum of squares.

#### 12. SIGNIFICANCE TESTS IN PAIRED COMPARISONS.

T. H. Starks and H. A. David; *Virginia Polytechnic Institute*

Approximate tests of significance must be used for paired comparison experiments that lie outside the range of the tables by Bradley and Terry, Bradley, and Kendall and Babington-Smith. This paper specifies certain general model assumptions for the paired comparisons experiment, and there presents approximate tests of significance for the following null hypotheses:

- 1) The treatments have equal ratings (single judge);
- 2) The treatments have equal ratings (several judges);
- 3) The true treatment ratings do not change from judge to judge.

The alternative hypothesis in each case is that the corresponding null hypothesis is not true.



The test statistics introduced for tests of the first two null hypotheses are functions of the corrected sum of squares of treatment scores, and they are distributed approximately as chi-square variates. The approximate test of the third null hypothesis is based on the theory of chi-square homogeneity tests.

13. GENERALIZED DISTRIBUTIONS AND THE PROBLEM OF CONFIDENCE STATEMENTS IN MULTIVARIATE ANALYSIS.

Rolf E. Bargmann; *Virginia Polytechnic Institute*

The convenient likelihood-ratio approach for the construction of tests in multivariate analysis does not lend itself readily to the construction of confidence intervals. The speaker reported on some existing techniques of constructing multivariate confidence intervals, with levels  $\geq 1 - \alpha$ , from the "union-intersection approach" of S. N. Roy. He then proceeded to some results he obtained by studying the distributions of generalized  $X^2$  and  $F$  matrices, and the general non-central distribution of all elements in a correlation matrix. Exact confidence statements can be obtained for some parametric functions, such as the determinant of a population dispersion matrix, and the ratio of determinants of two such matrices, but these parametric functions are rather meaningless in that they never assume a unique central value. Confidence statements on the very powerful functions similar to the likelihood-ratio statistics cannot be obtained in this manner, for the resulting expressions contain sample and parametric quantities in a mathematically inseparable expression. (Reference: Rolf E. Bargmann, "A Study of Independence and Dependence in Multivariate Normal Analysis", Chapter III; Institute of Statistics, University of North Carolina, 1957).

14. STATISTICS OF DIRECTION.

G. S. Watson; *Australian National University*

In geological and geophysical problems, the variables of interest are often directions. For example, in palaeomagnetism the main interest centers around the residual or remnant magnetism of rocks of various ages. Since the strength of the magnetism may be subject to many unknown factors which do not operate on the directions of the magnetization, it is the later variable that is easiest to use. In geology the orientation of plain layer of formation is defined by the direction of their normals.

Probability distributions for directions in any number of dimensions have been proposed to define explicitly how the observations will be dispersed about the mean direction. Statistical methods for the comparison of mean directions and of dispersions have been developed. The approxi-

mate forms of true procedures bear a striking resemblance to multivariate normal analysis. The exact procedures which may be used in some instances are of considerable theoretical interest as they throw into clearer relief the famous Behrens-Fisher problem.



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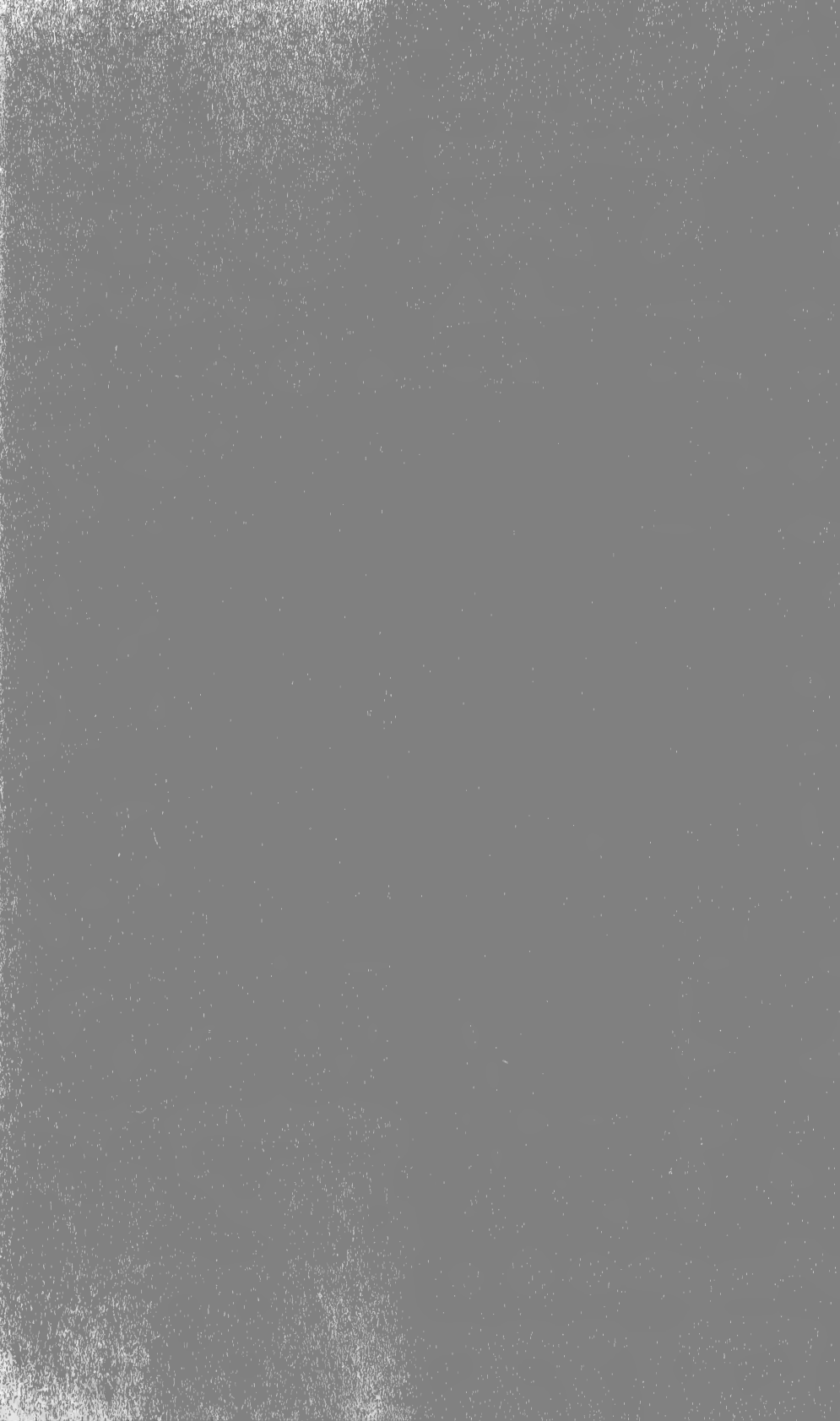
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